STUDIES RELATED TO WILDERNESS
PRIMITIVE AREAS

POPO AGIE, WYOMING

GEOLOGICAL SURVEY BULLETIN 1353-B

Mineral Resources of the Popo Agie Primitive Area, Fremont and Sublette Counties, Wyoming

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With a section on INTERPRETATION OF AEROMAGNETIC DATA

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An evaluation of the mineral potential 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 bulletin reports the results of a mineral survey of the Popo Agie Primitive Area, Wyo., and some adjoining national forest lands that may be considered for wilderness designation.

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MINERAL RESOURCES OF THE POPO AGIE PRIMITIVE AREA, FREMONT AND SUBLETTE COUNTIES, WYOMING

By ROBERT C. PEARSON and THOR H. KIILSGAARD, U.S. Geological Survey, and by LOWELL L. PATTEN, U.S. Bureau of Mines

SUMMARY

A mineral survey was made of the Popo Agie Primitive Area, Wyo., by the U.S. Geological Survey and U.S. Bureau of Mines in 1969 and 1970. The area studied lies on the southeast flank of the Wind River Range and adjoins the east boundary of the Bridger Wilderness. It consists of about 100 square miles of the primitive area and about 60 square miles of contiguous land along the east side of the primitive area. Rugged alpine terrain characterizes most of this area, especially that part along the southwest boundary — the Continental Divide.

The mineral survey consisted of reconnaissance geologic mapping and extensive sampling. Outcrops of altered or possibly mineralized rocks were sampled and studied with particular care. Geiger-counter traverses were made along most of the main trails to test for radioactivity in the rocks. An aeromagnetic survey was made to search for geologic environments favorable for mineral deposition. County courthouse and Bureau of Land Management records were searched for information on mining claims, and the entire area was investigated for evidence of prospecting or mining. Several hundred miles of foot and horseback traverses were made during the course of the survey.

Two large plutons — quartz diorite of the Louis Lake batholith and porphyritic quartz monzonite of the younger Popo Agie batholith — occupy nearly the entire area. Only two small remnants of prebatholithic gneiss remain. The age of a small stock of albite-quartz rock relative to that of the batholiths is not known. Long dikes of diabase and feldspathic peridotite are the youngest rocks in the area.

More than 500 samples were collected and analyzed by spectrographic and chemical techniques. Most of the samples are of stream sediments, some are pan concentrates of stream gravels, and the rest are of fresh and altered rock. Analyses of these samples did not suggest the presence of commercial deposits of ore minerals or of potential mineral deposits. Likewise, the aeromagnetic survey did not reveal any evidence of potentially mineralized areas.

Mineral deposits of commercial value are not known in the area and nothing was found to indicate that potentially commercial deposits might be

present. No evidence of digging was seen in the area, nor are there records of old recorded mining claims. Since 1965 three groups of claims have been located that extend into or are adjacent to the area studied. One group of claims is in the vicinity of Big Sandy Mountain, along the west boundary of the area. A molybdenum prospect about 3 miles west of the primitive area boundary served as focus for that claim staking, but no evidence of molybdenum was seen on claims in or near the primitive area. Two groups of claims are located along the east side of the Popo Agie area, one in the vicinity of Roaring Fork Creek and the other on Townsend Creek. The claimants evidently were searching for uranium, but no uranium minerals or unusual radioactivity were found in the areas during this investigation. Several shallow drill holes were found that had explored the claims.

This investigation did not find any metallic or nonmetallic deposits in the Popo Agie area, nor any geologic criteria that suggest possible potential deposits. Petroleum, coal, and other mineral commodities normally found in sedimentary rocks are not likely to be found in the Precambrian crystalline rocks that underlie the area.

INTRODUCTION

This report discusses the results of a mineral survey of the Popo Agie Primitive Area in the Shoshone National Forest and of certain adjacent national forest lands, Fremont and Sublette Counties, Wyo. The primitive area consists of about 100 square miles of beautiful alpine terrain on the east side of, and near the south end of, the Wind River Range (fig. 1). The adjacent national forest lands, an area of about 60 square miles, are along the east boundary of the primitive area. The entire area that was studied, approximately 160 square miles, is referred to in this report as the Popo Agie area.

The northeast corner of the Popo Agie Primitive Area lies about 18 miles west of Lander, Wyo. The crest of the Wind River Range — the Continental Divide — bounds the primitive area on the southwest, and the Wind River Indian Reservation bounds it on the north. The east and south boundaries of the study area are on the lower flanks of the range. The Bridger Wilderness is contiguous to the primitive area and lies southwest of the Continental Divide.

The scenery of the area is dominated by deep glaciated canyons that head in large compound cirques (fig. 2) against the Continental Divide or against high ridges that lie east of the divide. Some of the ridges above the headwalls of the cirques are jagged arêtes, but where glacial erosion has not proceeded so far, a flat or gently rolling mature erosion surface remains atop the ridges (figs. 3, 10). The major canyons that leave the area are occupied from north to south by the South Fork Little Wind River, North Popo Agie River, and the Middle Popo Agie River. The southern part of the area is drained by streams that join to form the Little

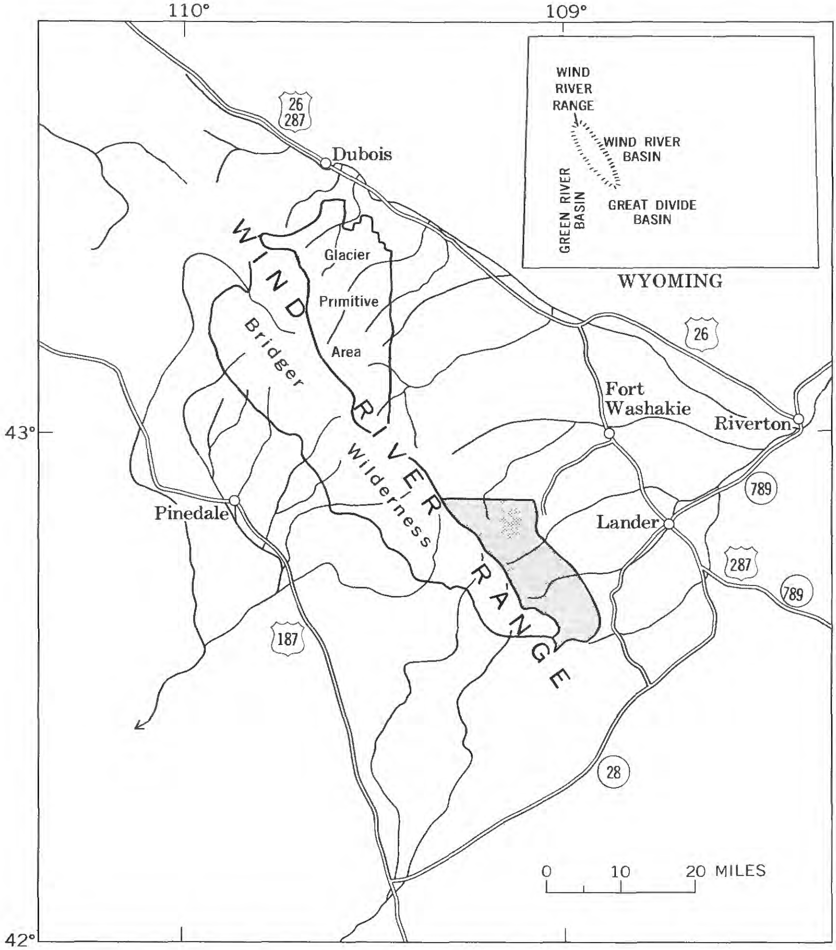

FIGURE 1.— Index map of western Wyoming, showing Popo Agie area (patterned).

Popo Agie River. The highest point along the crest of the range in the area is Wind River Peak at an altitude of about 13,225 feet. Elsewhere along the crest the peaks are mostly at altitudes between 12,000 and 12,500 feet. Trunk streams leave the area at altitudes of 8,500 to 9,000 feet.

The striking scenery of the Popo Agie Primitive Area, as well as that of most of the rest of the high parts of the Wind River Range, is hardly visible from the nearest main highway — U.S. Highway 287 — which parallels the range on the northeast. The view is obscured by the hogbacks of tilted sedimentary strata that rise out of the Wind River Basin (fig. 1) and form the foothills of the range. Secondary roads that provide access to the

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FIGURE 2. — Cirque of the Towers at the head of the North Popo Agie River, viewed from Lizard Head Meadows.

primitive area also provide striking views of the high country, but much of it is visible only from within the area itself. The three main access routes into the area are via Dickinson Park, Sinks Canyon, and Sweetwater Gap. A poor 4-wheel-drive road leads from Lander over Cyclone Pass to Shoshone Lake, which is near the east boundary of the area. Dickinson Park is a trailhead outside the northeastern part of the primitive area and is reached by 20 miles of gravel road from U.S. Highway 287 near Fort Washakie. From Dickinson Park, trails lead to the South Fork Little Wind River, the North Popo Agie River, and Smith Lake Creek. Parts of the area in the vicinity of the Middle Popo Agie River are accessible by trail up the Middle Popo Agie from the hard-surfaced Sinks Canyon road, by trail from Frye Lake on the Louis Lake road (a continuation of the Sinks Canyon road), and from the south by trail through Sweetwater Gap into the headwaters of the Middle Popo Agie.

Most of the area is above timberline, where bare rock, felsenmeer, talus, lakes, and snowfields dominate the landscape. Also, a few small glaciers remain on the north sides of peaks and ridges; the largest of these glaciers are on Lizard Head Peak and Wind River Peak (fig. 3), the two highest peaks in the area. Glaciated valley and cirque walls are unusually steep in the massive and fresh granitic rocks. The north face of Hooker Mountain (fig. 4),

FIGURE 3. — Small glacier on the north side of Wind River Peak. Note small terminal moraine from 19th-century advance. Light-colored rocks between snowbanks above far tip of moraine are altered rocks discussed in text.

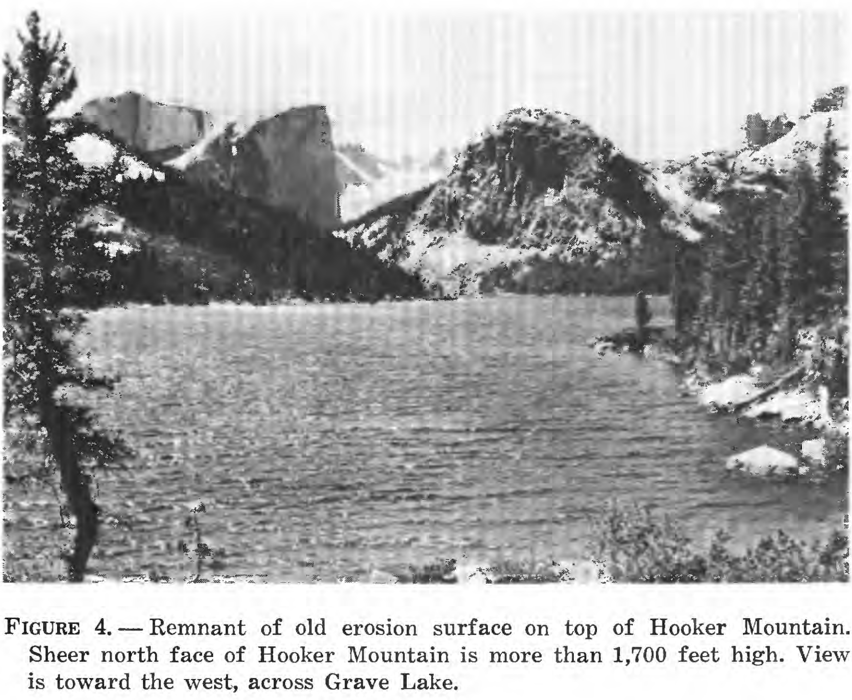

FIGURE 4. — Remnant of old erosion surface on top of Hooker Mountain. Sheer north face of Hooker Mountain is more than 1,700 feet high. View is toward the west, across Grave Lake.

as the outstanding example, rises more than 1,700 feet nearly vertically. Below timberline, trees grow thickly only on glacial moraines. The bare glaciated surfaces of much of the area support only sporadic and sparse forest growth. Lodgepole and limber pine are the dominant species, and Douglas-fir, alpine fir, and Englemann spruce are common.

There is no evidence of industrial activity in the Popo Agie area. No mineral deposits of commercial value, mines, or records of mining activity are known there. Logging does not seem to have been feasible in the sparsely forested and rugged region. Meadows along the larger streams and grassy upland slopes, however, support the grazing of sheep and cattle. The area is also well suited for recreation and is a popular vacation site for hiking, hunting, fishing, and mountain climbing. East of the area, along the front of the foothills and in valleys extending out into the Wind River Basin, a prosperous ranching industry is dependent largely on irrigation water that originates from heavy snowfall and rains in the high country. Very probably, this water is the most important resource derived from the Popo Agie area.

PREVIOUS STUDIES

Geologic studies of the Wind River Range have been concentrated on the sedimentary rocks that are found along the flanks of the range, and until the last decade geologists have virtually ignored the complex and inaccessible Precambrian rocks that form the major part of the range and that constitute the only rocks that crop out in the Popo Agie area. Among the earliest references to the Precambrian rocks are comments by St. John (1883), of the Hayden Surveys, who recognized that in the northern part of the range granitic rocks intruded older gneisses and that both of these were intruded by mafic dikes. One of the first attempts to subdivide the Precambrian rocks on a geologic map was by Richmond (1945), who showed the threefold division recognized by St. John. Oftedahl (1953) commented on a variety of rock types that he found on the west side of the range. The only prior geologic mapping in the Popo Agie area was by Parker (1962), who stressed the agmatites in a few square miles of the northwest corner of the area and in the adjacent Indian reservation. Most pertinent to the present study is the geologic mapping by Bayley (1963; 1965a,b) southeast of the Popo Agie area. The Louis Lake batholith of Bayley extends into the Popo Agie area. Other investigations that have emphasized structure and petrology are those by Worl (1963, 1968), Hodge and Worl (1965), Perry (1965), and Barrus (1968).

PRESENT WORK AND ACKNOWLEDGMENTS

Geologic fieldwork, consisting of mapping and sampling, was done by Pearson and Kiilsgaard in the Popo Agie area in July and August of 1969. They were assisted by Richard Hutchins and David Boleneus. Traverses were made along all trails, most streams, and many ridges. The samples were analyzed in mobile field laboratories of the U.S. Geological Survey by Arthur J. Toevs and David J. Grimes, and also in Survey laboratories in Denver, Colo.

Patten, U.S. Bureau of Mines, investigated the area in 1969 and 1970; he was assisted by David R. Alison. Patten examined county records for information on mining claim location and studied available publications for information on mineral deposits and mining activity. Further information was obtained from Forest Service personnel and from others familiar with the area. Patten and Alison also examined mining claims, on foot and on horseback.

An airborne magnetometer survey was flown in 1969. Analysis and interpretation of the aeromagnetic data were made by Robert E. Mattick, U.S. Geological Survey.

The good trail network and relatively open country permitted the use of horses for many geologic traverses and for moving camp. The excellent services of A and L Outfitters greatly aided the work, and we are indebted to them for their cooperation. A helicopter, capably piloted by Dan Hawkins, Hawkins and Powers Aviation, Inc., was used for several days for aerial observation and for transportation to localities that otherwise could be reached only with difficulty.

We thank several others who contributed to the success of this project. Forest Service personnel, particularly Hiram B. Smith, District Ranger, and Ferrell Jackson, Fire Guard at Dickinson Park, were very helpful in providing for our base camp in Dickinson Park, in relaying messages, and numerous other aids.

GEOLOGY

SETTING

The Popo Agie area lies entirely within the Precambrian core of the Wind River Range — a large northwesterly trending asymmetric anticline about 40 miles wide and 125 miles long. In age and structure the range is typical of the Rocky Mountain ranges. Sedimentary strata of Paleozoic and Mesozoic age were formerly continuous across the range, but they have been eroded from most of it and now exist mainly along the east flank, where remnants dip about 10°–15° off the Precambrian core and into the Wind River Basin. Along the west flank, equivalent sedimentary rocks have been largely eliminated from surface exposure by faulting, erosion, and burial by Cenozoic deposits. The range is bounded on the northeast by the Wind River Basin, on the southwest by the Green River Basin, and on the south by the Great Divide Basin — all of which have received fluviatile and lacustrine sediments during the entire life of the range. The anticline that constitutes the dominant structure of the range apparently plunges both northwest and southeast, inasmuch as altitudes decrease in these directions, and the sedimentary rocks seem to wrap around each end, although this relationship is obscured by overlapping Cenozoic deposits.

The Wind River Range began forming in Late Cretaceous time, during the Laramide orogeny (Keefer, 1965; Love, 1970, p. C114). Uplift and southwesterly directed thrust faulting mainly during Paleocene and early Eocene times formed the range as a structural element. Rapid erosion accompanied the uplift, and the resulting coarse detritus was deposited along the flanks of the range. During the rest of Tertiary time, erosion and deposition continued intermittently; canyons that had been cut earlier were filled, and some deposits lapped high onto the flanks of the range. Very late Tertiary uplift has since caused the Tertiary sediments to be stripped from the higher parts of the range. Glaciation was the last significant element in the development of the landscape. Icecaps covered large areas along the divide, and from them valley glaciers flowed down canyons that had been cut much earlier. The glaciers deepened the valleys, smoothed the valley walls, and piled up lateral and terminal moraines before melting and retreating a few thousand years ago. Most of the glaciers traveled considerably beyond the Popo Agie area, but in the northeast corner of the area, the Sand Creek, Ranger Creek, and Dickinson Creek Glaciers stopped near the edge of the mapped area.

The Precambrian rocks in the core of the range are exposed over an area of almost 2,000 square miles. Despite this large exposure and the fact that the initial explorations were made during the Hayden Surveys in the 1870's (St. John, 1883), the geology of the Precambrian rocks has been little studied until the last decade. And none of the recent studies have materially changed St. John's impression that the rocks are dominantly migmatitic gneisses and granitic rocks, both cut by mafic dikes.

An exception to this generalization is a belt of metasedimentary and metavolcanic rocks of low to medium metamorphic grade that forms part of the southeast end of the range. The impetus provided by the discovery of gold and iron deposits in this area resulted in geologic work by Spencer (1916) and by Bayley (1963, 1965a,b) ; Bayley deciphered the stratigraphy of the layered rocks and showed that they are bounded on the north by a large pluton of quartz diorite that he called the Louis Lake batholith. This batholith extends north into the Popo Agie area. Granger and others (1971), in geologic studies in the Glacier Primitive Area concurrent with this study, stated that the northern part of the range is dominantly migmatite and also consists of fairly large bodies of granitic rock. In the central part of the range, the gneisses seem to be less migmatitic, and they are, partly at least, of undoubted sedimentary origin (Perry, 1965; Barrus, 1968; Granger and others, 1971). Both Oftedahl (1953) and Parker (1962) mentioned agmatite as one type of migmatite in the northwest corner of the Popo Agie area and northwestward from there. The youngest Precambrian rocks in the range are diabase dikes, some of which have been deformed and metamorphosed. The youngest and undeformed diabase dikes are not abundant, but some of them are remarkably continuous.

The structure of the Precambrian rocks in the Wind River Range is even less well known than the distribution of rock types. Perry (1965) and Worl (1968) discussed large folds, and numerous shear zones and faults have been recognized in the northern part of the range (Richmond, 1945; Baker, 1946) that trend mainly subparallel to the present range. Some of the shear zones and faults show movement of the Paleozoic and Mesozoic rocks, as well as of the Precambrian rocks. The younger faults probably follow breaks of Precambrian ancestry, which suggests that Precambrian fault zones may have been zones of weakness that controlled the location and orientation of the range.

The age of some of the Precambrian granitic rocks in the Wind River Range, as determined by isotopic techniques, is 2,600–2,700 m.y. (million years), but the older gneisses are as yet undated. Bassett and Giletti (1963) determined that the potassium-argon and rubidium-strontium ages on minerals — mainly micas from pegmatite — range from about 1,500 to 2,860 m.y. ($Rb^{87} = 1.39 \times 10^{-11}yr^{-1}$). Naylor, Steiger, and Wasserburg (1968) reported convincing concordant dates on the Louis Lake batholith of 2,650 m.y. by rubidium-strontium ($Rb^{87} = 1.39 \times 10^{-11}yr^{-1}$) and 2,675 m.y. by the lead-uranium technique on zircon. Condie, Leech, and Baadsgaard (1969) obtained potassium-argon ages on the chilled border of undeformed diabase dikes that range from 900 to 2,060 m.y.; however, accumulated geologic evidence suggests to us that the dikes in the Popo Agie area are all the same age.

ROCKS

Migmatite

Migmatitic gneiss near Baptiste Lake in the northwest corner of the area (pl. 1) may be the oldest rock in the area. Parker (1962) referred to these rocks as "granodiorite gneiss" and showed that they and other paragneisses continue for at least 1 mile north of Baptiste Lake. The Glacier Primitive Area (Granger and others, 1971) contains large areas of similar migmatitic gneisses.

As shown in figure 5, the migmatite is a strongly layered rock composed mainly of various proportions of biotite, quartz, and feldspar. The layering and foliation dip steeply and strike northeast. Boudins and layers of nearly black amphibolite are common; these, Parker said, contain hypersthene, in addition to quartz, plagioclase, and amphibole. As shown in figure 5, the layers have been stretched and separated by flowage into lenses, wisps, and streaks. Some lenses have a cross section approximating a parallelogram, and others are irregular and jagged, owing to curved and tapering apophyses. To produce such structures the rock must have been readily mobile and perhaps partly molten, as is also suggested by the relatively coarse grain size of many layers and lenses that, in hand specimen, appear to be normal dioritic or granitic rocks.

FIGURE 5. — Migmatite, near Baptiste Lake.

The migmatite was apparently metamorphosed under considerably different conditions than the paragneisses 15 miles to the southeast on Tayo Creek, and we suggest that the two represent different sedimentary sequences that perhaps were metamorphosed at different times.

Paragneiss

Biotitic and hornblendic paragneiss crops out in a crudely elliptical ring along Tayo Creek near the head of the Middle Popo Agie River. The ring is about 1 mile wide and 2 miles long (pl. 1). The center of the ring of paragneiss is occupied by albite-quartz rock, and the ring is surrounded by foliated quartz diorite of the Louis Lake batholith. The ring-shaped outcrop results from erosion by Tayo Creek across a structural dome; a sheet of paragneiss about 600 feet thick was domed in such a way that its layering and the foliation in the overlying quartz diorite dip outward at an average of about 25°. The contacts with both the albite-quartz rock and the quartz diorite appear to be somewhat gradational and are tentatively concluded to be intrusive contacts.

The paragneiss consists mainly of thinly layered fine-grained hornblendic and biotitic gneisses and schists. A typical assemblage is hornblende, sodic andesine, biotite, and quartz; another is biotite, oligoclase, quartz, and, in small amounts, garnet. The layering and the composition suggest that the rocks originally were partly sedimentary and partly volcanic, even though no relict sedimentary or volcanic structures were found. They are metamorphosed to a grade comparable with that of metamorphic rocks south of the Louis Lake batholith (Hodge and Worl, 1965). Compositionally, the rocks in the two areas are also comparable, and they could be parts of the same sequence. No iron-formation or quartz veins were found in Tayo Creek rocks, as are present in the metamorphic rocks farther south. Neither did the aeromagnetic survey of the Popo Agie area disclose evidence of magnetic iron-formation.

Quartz Diorite of the Louis Lake Batholith

About the southern third of the area is underlain by gray even-grained weakly foliated biotite-hornblende quartz diorite that grades to granodiorite and locally to quartz monzonite. These rocks are presumed to be part of the Louis Lake batholith (Bayley, 1965a,b), which lies east and southeast of the Popo Agie area. Bodies of quartz diorite also occur in the northwest corner of the area and as remnants within the intervening, younger, Popo Agie batholith (pl. 1).

The quartz diorite of the Louis Lake batholith is intruded on the north by porphyritic quartz monzonite of the Popo Agie

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batholith, which is described below. The contact between the two batholiths crosses the entire Popo Agie area in a generally northeasterly direction, passing south of Wind River Peak and southeast of Mount Chevo. The contact is a broad diffuse zone that is in most places ¼–½ mile wide. The diffuseness is caused by (1) abundant intermixing of the two rocks taking the form of apophyses of porphyritic quartz monzonite and large inclusions of quartz diorite, and (2) small- to medium-sized bodies of granitoid rocks (alaskite, pegmatite, and so forth) that were intruded abundantly into both porphyritic quartz monzonite and quartz diorite particularly in the contact zone. Many outcrops show clearly that porphyritic quartz monzonite cuts across the foliated quartz diorite. Some cliff exposures illustrate the tendency for inclusions and apophyses to be approximately flat lying, a factor that in this rugged topography contributes to the irregularity of the contact zone.

The rocks in the northwest corner of the area that are labeled "quartz diorite" on plate 1 were referred to as agmatite by Parker (1962). This rock unit consists mainly of gray hornblendic equigranular rock that has been extensively diked and veined by light-colored granitic rocks, some at least derived from the Popo Agie batholith. As illustrated by Parker, the ratio between the two types ranges widely, but in most of the outcrops observed during this study, the older hornblendic rock is clearly dominant, and the leucocratic dikes form a sparse crisscrossing network that constitutes only a small percentage of the total. In such outcrops it is apparent that the hornblendic fraction, which has a composition mainly of quartz diorite, is not layered, is weakly foliated, and shows no petrographic evidence of having been metamorphosed before introduction of the granitic dikes. We suggest that the hornblendic fraction is quartz diorite of intrusive origin and, further, that it is a marginal phase of the Louis Lake batholith, now separated from that batholith by the Popo Agie batholith. Bodies of similar quartz diorite within the Popo Agie batholith are also interpreted as remnants of the Louis Lake batholith. However, the contact relations of these remnants to the surrounding porphyritic quartz monzonite are commonly complex, and they range from sharp (fig. 6) to very gradational.

The quartz diorite is gray and mostly equigranular, and it commonly has a faint to pronounced foliation. Both biotite and hornblende are conspicuous, and together they make up 10–25 percent of the rock. As seen in thin section, the rock also contains oligoclase or andesine, quartz, and minor amounts of microcline. Accessory minerals include magnetite, apatite, sphene, epidote, allanite, and zircon. Secondary minerals that are prominent

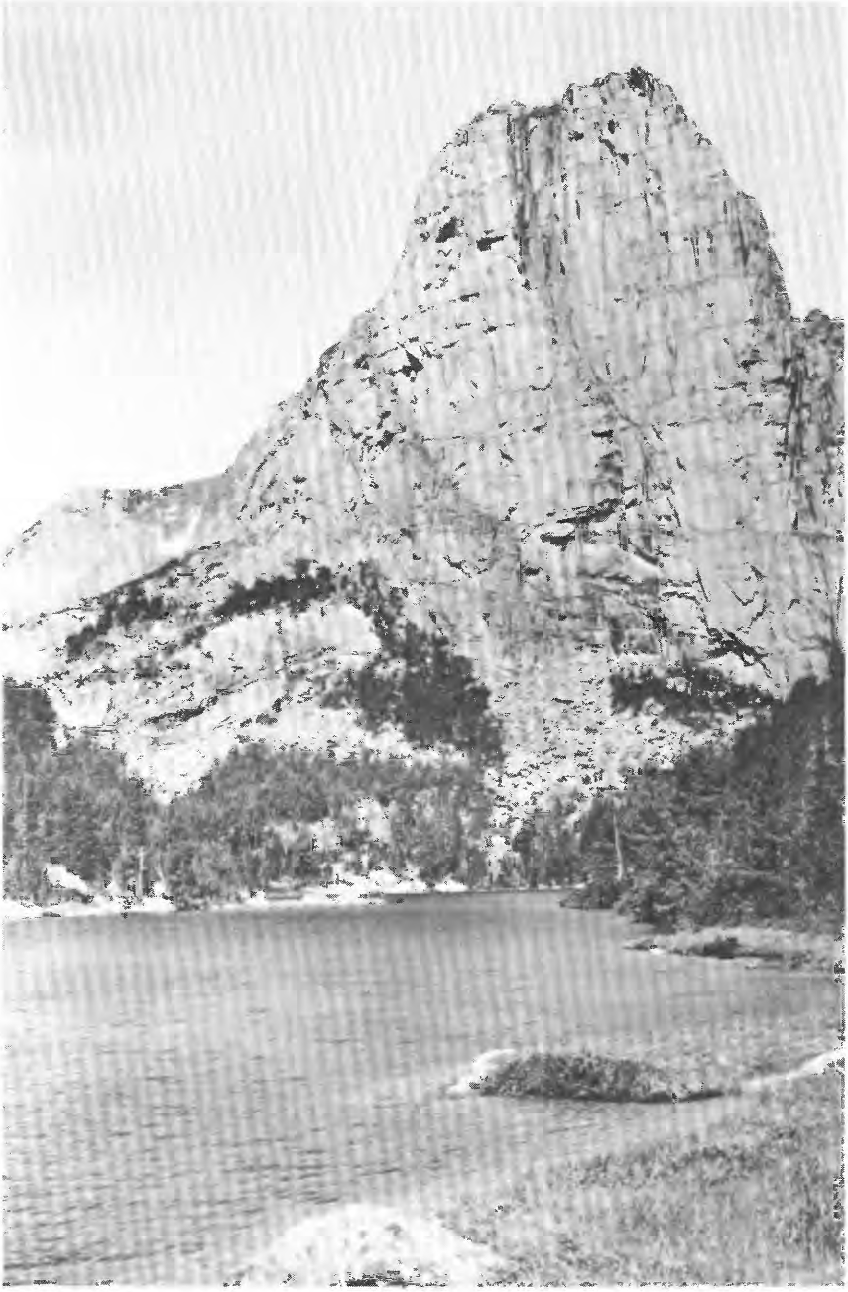

FIGURE 6. — Sharp contact of quartz diorite (dark) with porphyritic quartz monzonite (light) on cliff west of Cathedral Lake. Similar contact visible on distant ridge at left. Apophyses and inclusions show clearly that quartz monzonite is the younger; however, quartz diorite is most mafic at contact and quartz monzonite is most silicic at contact, and both grade into their respectively typical lithologies away from contact.

locally are scapolite, chlorite, actinolite, sericite, and "saussurite." Most specimens examined contain less than about 3 percent microcline, but some contain as much as about 20 percent. Clinopyroxene is present in only one specimen from about 2 miles south of Grave Lake, where it occurs as cores in hornblende crystals. The foliation is generally inconspicuous, but around the dome on Tayo Creek it is strong, although it decreases in intensity away from the dome.

Albite-Quartz Rock

An elliptical body of medium-grained albite-quartz rock occupies the core of the structural dome on Tayo Creek. The body is about 5,000 feet long and 3,000 feet wide and is surrounded by paragneiss that dips about 25° away from the core. Although the paragneiss is grossly concordant with the albite-quartz rock, the paragneiss is migmatitic, and inclusions of paragneiss are present in the albite-quartz rock. The albite-quartz rock is, therefore, the younger. The dip of the contact was not determined, nor was evidence seen to explain the coincidence of the albite-quartz rock and the dome.

The albite-quartz rock is nondirectional to weakly foliated, pale green to white, and equigranular. Weathered surfaces look like dirty snow, and freshly broken surfaces have a superficial resemblance to coarsely crystalline marble. One thin section of the rock contained about 88 percent albite, 10 percent quartz, 2 percent chlorite, and trace amounts of epidote, sericite, zircon, and apatite. This sample contained — by semiquantitative spectrographic analysis — only 0.15 percent calcium, much of which must reside in the accessory minerals; the albite, therefore, is virtually the pure end member.

The origin of uncommon albite-rich rocks has been much discussed. Albite granites and similar rocks have been interpreted (Gilluly, 1933) as being caused by replacement, and, indeed, albite-rich rocks in many places show convincing evidence of a metasomatic origin, such as the preservation in the albitic rock of structures and textures of the preexisting rock. Gilluly (1933) also cited cataclasis and graphic intergrowths as common to metasomatic albitic rocks. None of these features were noted in the Tayo Creek body during a very brief examination.

Sodic feldspar has been extracted from rocks similar to the Tayo Creek body for use by the glass and ceramics industries. An acceptable commercial product could probably be made by removing deleterious minerals by flotation or electrostatic separation. However, the remoteness of the area and the cost of transportation to principal users would probably price such low-unit-cost material above any foreseeable market.

Porphyritic Quartz Monzonite of the Popo Agie Batholith

A large pluton of porphyritic quartz monzonite, referred to in this report as the Popo Agie batholith (pl. 1), forms the central and northern parts of the Popo Agie area. Within the Popo Agie area the batholith is about 15 miles across in a northwesterly direction.

On the southeast side of the batholith, porphyritic quartz monzonite has intruded the quartz diorite of the Louis Lake batholith. This previously described intrusive contact is irregular and indefinite. Likewise, on the northwest side of the Popo Agie batholith, near Grave Lake, porphyritic quartz monzonite has intruded the quartz diorite. Similar quartz diorite, in bodies as large as 2 square miles, is present as remnants within the Popo Agie batholith. Contacts of the quartz diorite near Grave Lake, as well as contacts of the remnants, are sharp in some places but gradational in others. Where the contact is sharp (fig. 6), the porphyritic quartz monzonite is clearly the younger.

The porphyritic quartz monzonite consists of phenocrysts of microcline set in a groundmass of oligoclase, quartz, biotite, and, locally, hornblende. Accessory minerals are magnetite, sphene, allanite, epidote, apatite, and zircon. Sphene is conspicuous megascopically. Microcline is more abundant than plagioclase in some parts of the pluton, and plagioclase is dominant in other parts, but in most of the batholith the two feldspars are equally abundant. Nonporphyritic and hornblende-bearing varieties of the rock resemble the quartz diorite of the Louis Lake batholith.

The microcline phenocrysts range in length from about 2 inches to about one-half inch, where they begin to merge with the groundmass. The phenocrysts commonly are alined, and the resulting measurable planar or linear character of the rock is interpreted as primary flow structure, which is generally not apparent in the groundmass. In some outcrops, swarms of parallel phenocrysts gradually grade into areas where they have no detectable preferred orientation (fig. 7). The quantity of phenocrysts ranges from about one-third of the rock to almost zero.

Most outcrops are cut by sheets and veins of leucocratic rocks that are a fraction of an inch to a few feet thick. Sheets of pegmatite about 1 foot thick and veins of alaskite about 1 inch thick are particularly common. These tabular bodies crisscross in seemingly random directions.

Although slight differences in composition and texture are noticeable within and between outcrops, the nature of these inhomogeneities is fully apparent only on canyon and cirque walls. Thus, in such places as along the North Popo Agie River and in the South Fork Lakes cirques, a faint horizontal or gently dipping

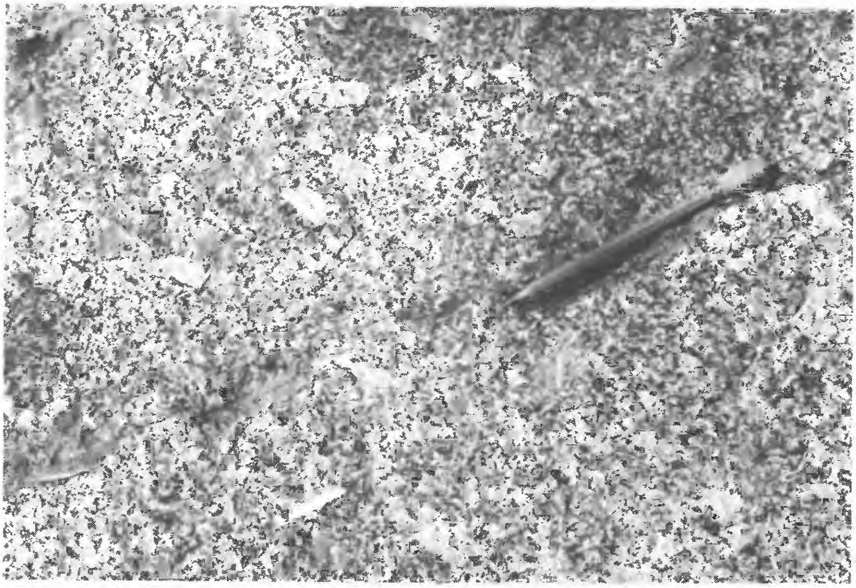

FIGURE 7. — Porphyritic quartz monzonite of the Popo Agie batholith. Outcrop is east of Cloverleaf Lake.

layering can be seen. As viewed on the 1,000- to 2,000-foot-high cliffs, the layers are several tens of feet to several hundreds of feet thick. Close inspection of the contacts between the layers reveals that the differences in lithology are minor and that one variant passes abruptly into the adjacent one, which forms a color contrast but no sharp contact or evidence of a difference in age. The layering is attributed to inhomogeneities in the crystallizing magma.

Biotite Quartz Monzonite of the Popo Agie Batholith

Rocks shown on plate 1 as biotite quartz monzonite are mostly pegmatite, alaskite, nonhomogeneous granitic rocks, and homogeneous medium-grained biotite quartz monzonite. They were mapped together as a unit only southeast of the Middle Popo Agie River, although small bodies of rock that would fit into this diverse unit cut all the granitic and metamorphic rocks in the area except the fine-grained quartz monzonite.

In the areas where these bodies are most widespread, as along upper Basco Creek, the contact is gradational with quartz diorite. Toward the contact of biotite quartz monzonite, dikes and irregular bodies seem to become more abundant and larger and to coalesce until only scattered inclusions of quartz diorite remain.

Biotite quartz monzonite weathers less rapidly than quartz diorite; consequently, in nonglaciated areas it stands out in relief, forms most of the visible rock in the felsenmeer fields, and tends to mask the dominant quartz diorite. On ridges above cirque headwalls, rocks akin to biotite quartz monzonite are almost the only ones visible, yet the cliffs below show clearly that quartz diorite is dominant and is merely laced with a network of sheets of biotite quartz monzonite.

The most characteristic rocks of the biotite quartz monzonite unit are inequigranular to equigranular, nonhomogeneous, light colored, and quartz monzonitic to granitic in composition. These alaskitic rocks grade into pegmatite on the one hand and into slightly more mafic and more homogeneous biotite quartz monzonite on the other; the latter rocks resemble quartz diorite nearby. Biotite, magnetite, and sphene are the mafic minerals, and they constitute generally 1–5 percent of the rock. In irregular ill-defined areas, these rocks contain microcline phenocrysts, which cause these rocks to be identical in appearance with the porphyritic quartz monzonite of the Popo Agie batholith. For this reason, most of the rocks of the biotite quartz monzonite unit are believed to be late-stage intrusions related to the Popo Agie batholith.

Fine-Grained Quartz Monzonite

Innumerable bodies of fine-grained equigranular gray quartz monzonite have intruded the Popo Agie and Louis Lake batholiths from the North Popo Agie River southeastward along the east side of the area. The bodies are mostly small and irregular, ranging in diameter from a few feet across to several tens of feet, but some are much larger and occupy more than 1 square mile. Only the larger bodies were mapped (pl. 1).

Typically, the rock consists of biotite, quartz, microcline, and oligoclase mainly, but accessories, such as magnetite, sphene, allanite, apatite, and zircon, are fairly abundant. The average grain size is about 1 mm (millimeter), and although the rock has an equigranular appearance, thin sections revealed a seriate texture with larger feldspars up to 3 mm long.

A variant of the typical fine-grained quartz monzonite contains prominent white spheroidal masses about one-half inch in diameter. These masses seem to differ from the typical rock around them only by being almost devoid of biotite; they consist of quartz, feldspars, and prominent sphene. These spotted rocks are particularly noticeable on Mount Chevo and in the area between the Middle Popo Agie River and Deep Creek, where they seem to be concentrated along the contact between the Popo Agie and Louis Lake batholiths.

Fine-grained quartz monzonite cuts the foliation in both the Popo Agie and the Louis Lake batholiths. Contacts are sharp but irregular. No contact effects are evident in the wallrocks.

Feldspathic Peridotite

The only rock approaching ultramafic composition is an irregular dike that trends northeastward through Washakie, Valentine, and Dutch Oven Lakes (pl. 1). Locally, the dike is not well exposed, and so, its thickness and continuity are not well known. It appears to be poddy, and its contacts tend to be irregular. The dike seems to dip steeply from Washakie Lake northeast, and it is as much as several hundred feet thick; from Washakie Lake west, however, the dip lessens to perhaps 25° S. at the place where it crosses the Continental Divide north of Washakie Pass. Oftedahl (1953, p. 15 and fig. 2) mentioned a mafic dike along Washakie Creek about 1.5 miles southwest of the pass that is probably this dike. If so, the dike is more than 8 miles long.

The feldspathic peridotite is tougher and, hence, forms more rounded outcrops than the diabase, which it superficially resembles. It is also slightly coarser grained and slightly lighter greenish gray than the diabase.

The rock consists of about 30 percent each of clinopyroxene, orthopyroxene, and olivine; about 10 percent labradorite-bytownite; and 1 percent or less each of biotite and magnetite. The glaciated outcrops are unusually fresh for a rock of this composition, but serpentine, uralite, and related minerals indicative of alteration are common. Just north of Dutch Oven Lake, very coarse grained amphibole borders the east side of the east branch of the dike.

The feldspathic peridotite cuts what are believed to be the youngest granitic rocks in the area, but its age relative to the diabase is unknown.

Diabase

Thick persistent dikes of diabase are characteristic of the Wind River Range and other Precambrian outcrop areas in Wyoming and southern Montana. Three large dikes and several small ones trend northeastward through the Popo Agie area.

In the northwest corner of the area (pl. 1) a large dike passes through Baptiste Lake, and another passes through Grave Lake. These two join about 5 miles to the northeast (Parker, 1962). Assuming that the dike which passes through Baptiste Lake is the same one reported by Oftedahl (1953) at Silver Lake on the west side of the range, the dike is more than 20 miles long. The southeasternmost of the three large dikes (fig. 8) is known to be more than 14 miles long. Granger and others (1971) reported even longer diabase dikes about 30 miles to the northwest. The three large dikes in the Popo Agie area each average about 150 feet in thickness.

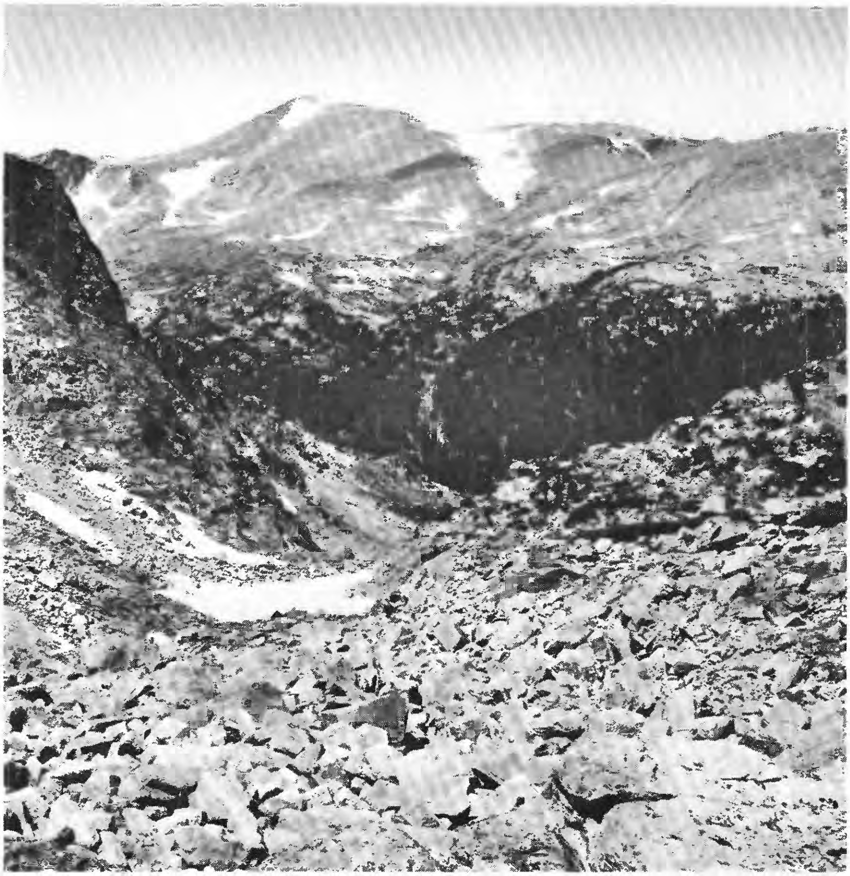

FIGURE 8. — Diabase dike (dark stripe) crossing the east flank of Wind River Peak. View is toward the northwest.

The diabase is dark greenish gray and weathers to reddish-brown surfaces. In the central parts of the thicker dikes, the rock is as coarse as medium-grained gabbro, whereas near the margins it has the fine-grained texture typical of chilled borders. The coarser grained central parts have a subophitic texture and consist of fresh lath-shaped labradorite and variably altered augite and pigeonite. Small quantities of biotite are probably primary. Quartz, which constitutes less than 1 percent of the rock and forms graphic intergrowths in plagioclase and late interstitial crystals, is, along with the biotite, evidence of contamination from the wallrocks. Xenocrysts of quartz and feldspar and small granitic inclusions are common in the chilled margins but are rare in the coarser grained interior, where they have been melted and assimilated.

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Jointing in the dikes has produced a blocky structure, and the larger pieces of the rock tend to weather into subrounded boulders. The dikes have been readily attacked by glacial erosion that has scoured them and plucked boulders that are now strewn in moraines and alluvium. The diabase weathers readily to a reddish-brown soil, and commonly the weathered dikes present exposures of low relief. They tend to form saddles in ridges and swales across the more eroded areas.

Altered Rocks

Two northerly trending zones of unusual altered rocks cross the crest and the east flank of Wind River Peak. The zone that crosses the crest is at least 1.5 miles long, and in the cirque north of the peak it is about 500 feet wide (fig. 3). The second zone parallels the first about 0.5 mile to the east. It is smaller than the first, but its dimensions are not well known. The smaller zone appears to be cut by the diabase dike that crosses the east flank of Wind River Peak (fig. 8).

The rocks that form the altered zones are pale colored and contrast with the unaltered quartz diorite and quartz monzonite country rocks that are mottled by biotite and hornblende. The altered rocks are mainly fine- to medium-grained aggregates of quartz and plagioclase. The plagioclase varies greatly in composition, from albite to bytownite. In the rocks that appear texturally to be most completely altered, the plagioclase is labradorite or bytownite. Green, light-brown, or pink epidote or zoisite is unevenly distributed, but commonly forms alined clusters or lenticles that give the rock a faintly planar structure. Crystals of dark-brown sphene as much as about 2 mm long are conspicuous but not abundant. Irregular veins of quartz or green epidote, or both, ramify through the altered rock. Locally, near the top of Wind River Peak, subspherical masses (0.5–1 in. in diameter) of radiating crystals of pale-green diopside and tremolite are scattered through a matrix of granular white quartz. Semiquantitative spectrographic analyses of six samples of altered rocks (table 1, samples 190, 192, 472, 559, 560, and 561) did not indicate that economically important elements had been concentrated during the alteration. Chemically, the alteration involved expulsion of iron and alkali metals and introduction of calcium.

Locally, faint relicts of texture or structure of the original rock are visible in the otherwise completely altered rocks. Microcline phenocrysts have been replaced by aggregates of quartz and plagioclase, but the forms are still discernible in a matrix now composed mainly of the same two minerals. Similarly, the medium-grained equigranular quartz diorite can be recognized by the relict texture as the rock that was altered. Although some of the altered rocks resemble tactite, there is no evidence that any rocks other than the present granitoid country rocks were involved.

QUATERNARY DEPOSITS

Glacial Deposits

Three ages of glaciation were recognized in the Popo Agie area, but the moraines that were formed during the glaciations are not distinguished by age on the geologic map (pl. 1). The principal glaciers of the area continued beyond the mouths of the canyons at the foot of the range for short distances out onto the plains, where they deposited terminal moraines that are probably partly of Bull Lake and partly of Pinedale age (G. M. Richmond, oral commun., 1971). The main lateral moraines in the Popo Agie area show local evidence of being of more than one age, also. Differences were noted from place to place in the amount of weathering of boulders and in their size and number. Also noted in the prominent lateral moraine between Dickinson Park and the North Popo Agie River is a steep-sided moraine ridge that crosses subsidiary ridges of an older moraine that is broader and has a more subdued topography. The two probably represent separate glaciations — presumably Bull Lake and Pinedale. Farther up the main valleys the lateral moraines are insignificant, and the only widespread glacial deposits are ground moraines on the valley floors (fig. 2).

In a few of the cirques, small terminal moraines (fig. 3) and other morainelike accumulations of angular debris give evidence of a rather recent glacial advance. Where the glacier remains, a small lake between the glacier and the moraine indicates recession since the presumed maximum late in the 19th century.

Alluvium

Gravel and sand have been deposited along the major valleys where the glaciers have overdeepened stretches of the trough floor. Although some of these depressions still contain lakes, many have been aggraded to the rock bar at their lower end. Moraines also have dammed minor tributaries, providing traps for alluvium. These deposits are covered by a layer of peaty soil that supports a dense growth of grass and willows.

None of these accumulations are of commercial importance.

Felsenmeer

Most gently sloping surfaces above timberline and above the level of glaciation are covered by felsenmeer — a blanket of angular blocks derived from the bedrock by frost action. These blocks have not moved far; they have simply moved downslope under the influence of frost action and gravity. Few outcrops project through the felsenmeer. Flatter areas in broad saddles or on ridgetops are covered with sandy grus that was formed by very intense frost action. Boulders poke through the sand here and there, and stone nets are poorly developed in some sandy areas.

STRUCTURE

In its overall structure the Wind River Range is similar to many of the Rocky Mountain ranges, and it is one of the largest. The range began forming near the end of the Cretaceous Period with the onset of arching that continued into the Eocene Epoch (Love, 1970). Erosion removed the layered sedimentary rocks from the higher parts of the arch during the period of rapid uplift, exposing the Precambrian rocks in the core of the anticline. The tilted remnants of these once-continuous formations remain as hogbacks along the east side of the range. No hogbacks remain on the west side, for there, thrust faulting culminated the period of arching, and the tilted sedimentary rocks were overridden by Precambrian rocks. Eastward from their now-buried trace, the thrust faults presumably steepen, and do not extend eastward beneath the Popo Agie area.

Although displacement along some smaller faults in parts of the range occurred in Tertiary time, the major structures recognized in rocks in the Popo Agie area probably all originated during the Precambrian. These old structures include layering and foliation in the metamorphic and batholithic rocks, faults of several directions, and a small dome involving paragneiss and granitoid rocks. The layering and foliation in the rocks of the Louis Lake and Popo Agie batholiths are interpreted as magmatic-flow features, except perhaps around the dome. An additional structural episode is postulated from the northeast-trending dikes of diabase and feldspathic peridotite. No evidence of faulting was found along the dikes, but at least they document a period of fracturing, presumably tensional, of regional extent that occurred after plutonism but before the main period(s) of faulting.

The faults that offset all the Precambrian rocks in the area are elements of fault systems that are known in several parts of the range (Richmond, 1945; Baker, 1946; Granger and others, 1971). Most of these faults either parallel the range or are at right angles to it.

The largest and most conspicuous fault in the Popo Agie area is the South Fork fault, which follows the South Fork Little Wind River for about 4 miles. It was mapped for 10 miles in the area and can be inferred from topographic lineaments and offsets visible on aerial photographs to extend for at least 20 miles. The South Fork fault trends about N. 20° W. and dips 45°–65° SW.

The width of the fault zone increases southward from about 20 feet in Raft Creek (just north of the area) to about 500 feet east of Big Sandy Mountain (fig. 9). As seen in numerous exposures, the fault zone consists of variably crushed and altered rock — mostly breccia and some gouge. Mineralization and alteration of original rock-forming minerals along the fault produced prominent red and green minerals. The green colors are caused by chlorite and epidote that have formed in the fault zone. The red colors are caused by very fine dust — presumably hematite — in the quartz and feldspar; commonly the feldspar in and near the fault is bright salmon colored or orange. In addition to epidote, coarse-textured quartz and specularite or magnetite occur locally along the fault. Other faults in the area are distinguished by breccia and by the red and green minerals in and along them. These minerals are believed to have formed under conditions of temperature and depth that have probably not prevailed there in Phanerozoic time; hence, the presence of these minerals is the main reason for dating the initial faulting as Precambrian.

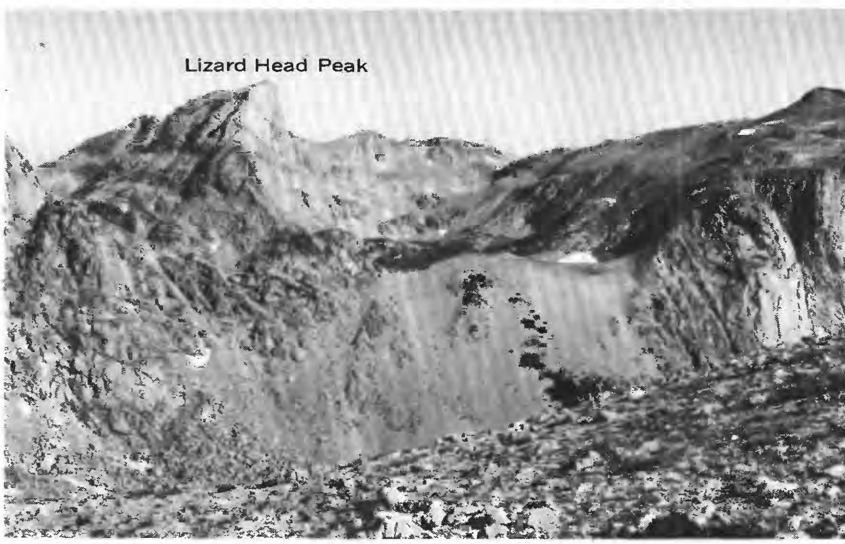

FIGURE 9. — Broad crushed zone (center) where South Fork fault crosses a ridge about 1 mile southeast of Lizard Head Meadows. View is toward the north-northwest from ridge east of Big Sandy Mountain. Note that preglacial erosion surface on skyline, at right, slopes westward toward the South Fork fault. Smooth surface at the summit of Lizard Head Peak may be a remnant of the same west-sloping erosion surface that has been upfaulted more than 1,000 feet since the surface was formed. The fact that both surfaces slope westward, even though they are as much as 2 miles east of the orographic divide, suggests tilting due to faulting.

A few other faults having about the same N. 20° W. trend are west of the South Fork fault, and numerous other faults of the same trend are suggested by lineaments still farther west, beyond the area mapped. The fault that extends northward from Hailey Pass to Baptiste Lake is alined with a fault that continues north from the lake, as mapped by Parker (1962).

In the southern half of the area, several faults trend west to west-northwest (fig. 10). These faults dip 75°–90° either north or south. The one fault of northeasterly trend extends from Coon Lake on the Continental Divide northeastward to Three Forks Park, where it presumably joins with the faults along Deep Creek.

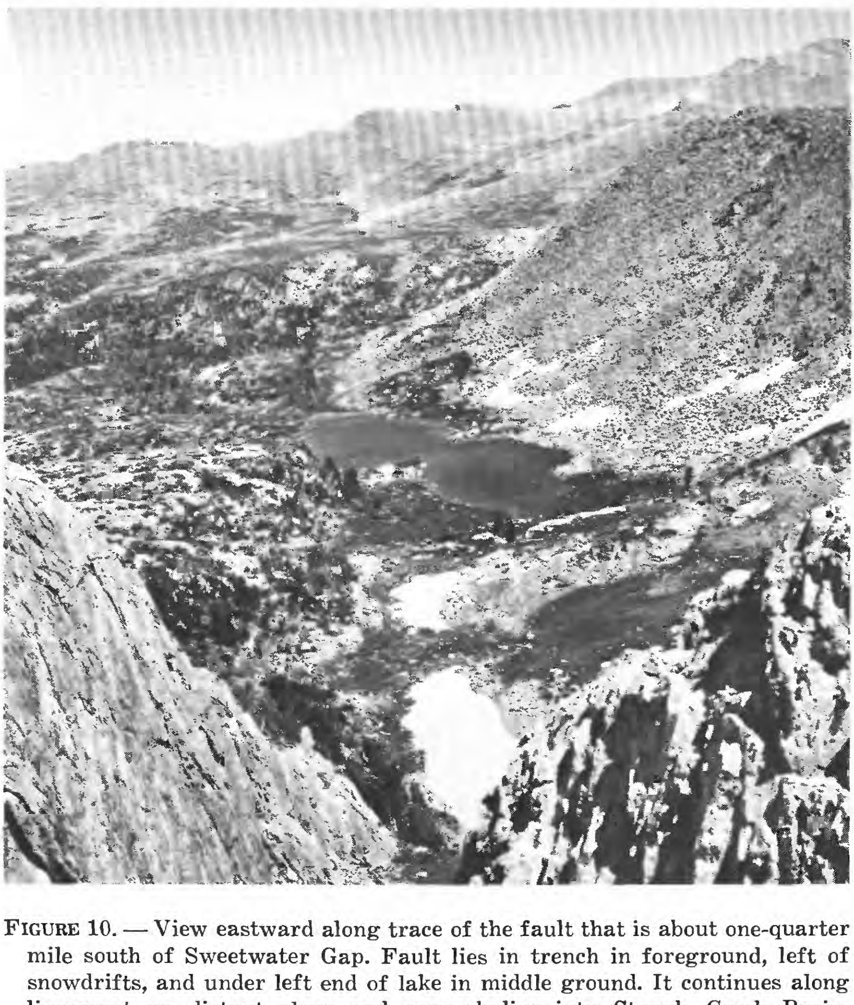

FIGURE 10. — View eastward along trace of the fault that is about one-quarter mile south of Sweetwater Gap. Fault lies in trench in foreground, left of snowdrifts, and under left end of lake in middle ground. It continues along lineament on distant slope and over skyline into Stough Creek Basin. Photograph was taken from ridge 1 mile west of Sweetwater Gap.

Displacement of the diabase and feldspathic peridotite dikes indicates a right-lateral offset of about 2,000 feet along the South Fork fault. As these dikes dip steeply and as slickensides suggest predominant dip-slip movement, the observed lateral component is probably much less than the vertical component. Nearly vertical diabase dikes also are offset by two westerly trending faults that pass through Deep Creek Lakes; left-lateral movement of 1,400 feet and 200 feet is indicated (pl. 1). Likewise, the fault through Hailey Pass and Baptiste Lake offsets a diabase dike about 200 feet left laterally, west of the Continental Divide. No intersections of the northerly trending faults with the westerly trending faults occur in the area. Examination of aerial photographs, however, suggests that the two sets cross one another west of the Continental Divide with little or no offset.

INTERPRETATION OF AEROMAGNETIC DATA

By ROBERT E. MATTICK, U.S. Geological Survey

In the summer of 1969, the U.S. Geological Survey flew an aeromagnetic survey of parts of the Wind River Range including the Popo Agie Primitive Area, but excluding the area around Cony Mountain. The aeromagnetic data were obtained along 30 east-west flight lines spaced about 1 mile apart, flown at a barometric elevation of 13,500 to 14,500 feet depending on local topography. The magnetic data were compiled relative to an arbitrary datum at a scale of 1:62,500 and were contoured at an interval of 20 gammas (pl. 1). No laboratory measurements of rock magnetic properties were made.

Magnetically, the Popo Agie area is characterized by a broad magnetic high of low amplitude over the Popo Agie batholith, which is composed dominantly of porphyritic quartz monzonite. The areas of dominantly quartz diorite that lie north and south of the Popo Agie batholith average about 300 gammas less in magnetic intensity. Superimposed on the broad features are numerous closed positive and negative anomalies that have medium wavelengths (2–3 miles) and steep gradients. Some of these, such as the highs over Mount Chevo and Wind River Peak, may reflect topography; others, such as the lows along the South Fork fault and over the albite-quartz rock on Tayo Creek, reflect rocks having lower susceptibility; and still others, such as the high about 1 mile northeast of Lizard Head Meadows, may reflect the irregular distribution of ferromagnetic minerals within the rock units shown on the map. Depth analyses, based on the gradients of the magnetic anomalies (Vacquier and others, 1951), indicated that the sources of all these anomalies are at or near the surface.

The magnetic low that coincides with the stock of albite-quartz rock has a minimum value of 6,613 gammas — the lowest in the area. The albite-quartz rock contains a very small percentage of mafic minerals and little or no magnetite; thus, it contrasts strongly with the more magnetic rocks around it. The closed low over the albite-quartz rock is oriented parallel to the outcrop of the stock, but it has an area several times that of the exposed stock, an indication that the stock may enlarge with depth.

The South Fork fault is the most prominent fault in the area and the only one that shows any magnetic expression. A residual low of 20–100 gammas parallels the fault along the west side, at a distance of about one-half mile. The low is continuous despite interruption by local anomalies and probably is caused by the alteration of magnetic minerals in the breccia and gouge along the fault. Locally, altered rocks along the fault are more than 500 feet thick, and some alteration extends even farther into the country rock. The westerly dip of 45°–65° measured on the South Fork fault accounts for the fact that the low lies west of the trace of the fault.

A notable feature of the map is the total lack of magnetic expression of either the diabase or the feldspathic peridotite dikes. Both of these rock types are more mafic than the enclosing rocks and are usually characterized by moderate to high magnetic susceptibilities. The absence of any expression of them in the geophysical data is best explained by their small width in relation to their distance below the aircraft.

None of the magnetic anomalies in the primitive area appear to warrant further geophysical study from the standpoint of mineral resource potential. All of them seem to originate at or near the surface of the exposed crystalline rocks, which, according to the geologic data, contain no apparent mineral deposits.

MINERAL RESOURCES

Emphasis in this study was directed to the search for mineral deposits and for geologic environments that might indicate potential mineral deposits in and near the Popo Agie Primitive Area. The study included a search for mining claims or evidence of mining or prospecting, and geologic, geochemical, and geophysical investigations. No evidence of mineral resources of potential value was found, nor were any localities seen that might be considered as favorable for future mineral discoveries. Coal, oil, and gas are not to be found in the Precambrian crystalline rocks that underlie the entire area.

SETTING

The Precambrian rocks of Wyoming, including those of the Wind River Range, have yielded sparse mineral deposits. In contrast, petroleum, coal, uranium, phosphate, trona, and other commodities are produced from the sedimentary rocks in basins surrounding the ranges. These sedimentary rocks do not underlie the Popo Agie area. Likewise, there is no evidence in the Popo Agie area of deposits of base metals and associated precious metals, such as characterize the neighboring States of Montana, Idaho, Utah, and Colorado. Those mineral deposits are associated, for the most part, with igneous rocks of late Mesozoic or Tertiary age which are not present in the Wind River Range.

Thus, the only types of mineral deposits that are known in the range and that might be anticipated from a knowledge of the geologic environment are substantial deposits of iron and small amounts of gold, uranium, and molybdenum.

The iron ore occurs in metasedimentary and metavolcanic rocks about 10 miles southeast of the Popo Agie area. Thin beds of sedimentary iron-formation have been thickened by intense folding, and sizable bodies of low-grade ore have been formed. These bodies of iron-rich rock were recognized easily by the early prospectors, but it was not until the 1950's and only after the techniques for processing taconite ores were found and the demand for iron ore increased that development of them became feasible. Metamorphic rocks similar to those that contain the iron-formation are present in the Popo Agie area in only one small area along Tayo Creek, but no iron-formation was observed there.

Gold was mined in the Atlantic City district, some 10 miles southeast of the primitive area. The gold was recovered from quartz veins that cut the same sequence of metasedimentary and metavolcanic rocks that contain the iron deposits. Discovery of the gold in the mid-1800's prompted a short rush to the district, but the results were disappointing. Subsequent mining activity has been sporadic, and total production has been small. During the rush, prospectors must have searched the Popo Agie area, but they evidently found nothing, for no evidence of digging was seen nor are there old records of any recorded claims. No quartz veins comparable to those of the Atlantic City district were seen in the Popo Agie area.

Placer gold is known in the northern part of the range, some 50 miles north of the Popo Agie area, but attempts to mine the fine, flaky gold were discouraging (Granger and others, 1971).

Uranium also is present in the northern part of the range, where very small amounts seem to be concentrated in shear zones near the surface. Granger and others (1971) suggested that both the placer gold and the uranium are associated with Tertiary events in the area: that the placer gold is a remnant of a layer of gold-bearing conglomerate that has been mostly eroded, and that the uranium may have been leached out of tuffaceous beds of Tertiary age and deposited in permeable fracture zones in the underlying Precambrian rocks. The Popo Agie area was prospected for uranium in the 1950's without success.

Molybdenum is known about 3 miles west of the primitive area in an unusual type of deposit that is discussed further on page B33.

GEOCHEMICAL EXPLORATION

A geochemical survey was made at the same time as the geologic reconnaissance. Samples for analysis were collected of stream sediment, panned concentrates of stream gravel, and fresh and altered rock. The purpose was to discover minor quantities of metals that might lead to a mineral deposit. More than 500 samples were analyzed, but none of them suggest the presence of mineral deposits.

Stream-sediment samples were collected from near the mouth of nearly every small stream and were collected at intervals of ½–1 mile along the medium-sized streams. The larger streams like the North Popo Agie and Middle Popo Agie Rivers were, in general, sampled only by panning: any anomalous metals entering the lower stretches of such large streams would be so diluted as not to be detectable. Rather, the effort was made to sample the small tributaries before they entered the large stream. Stream-sediment samples were chosen from the finest grained active-stream sediment available. As all samples were sieved and only the minus-80-mesh fraction was analyzed, an effort was made to collect sediment that was silty or muddy. However, many of the streams have very high gradients and do not deposit such fine-grained sediment. Where stream sediment of the appropriate grain size could not be found, underwater samples were taken of the muddy bank sediment. This old alluvium was in direct contact with the stream water and presumably would adsorb metal ions as effectively as active-stream sediments.

Splits of the minus-80-mesh fraction of the stream-sediment samples were analyzed for about 30 elements by semiquantitative spectrographic analysis; for combined copper, lead, zinc, and cobalt by the citrate-soluble heavy-metals test (cxHM); and for uranium by paper chromatography. Panned samples and rock samples were analyzed by semiquantitative spectrographic analysis, and the rock samples were also analyzed for gold by atomic absorption. The results of these analyses and tests are listed in tables 1, 2, and 3. Analyses for uranium and gold are not listed, because the results were nil.

Examination of the analytical data in table 1 illustrates the nonmineralized character of the rocks of the Popo Agie area. Analyses of samples of fresh rock merely reflect the composition of most of the different kinds of rock exposed in the area, which vary widely in content of certain metals. The content of copper, for example, ranges from less than 5 ppm (parts per million) in some of the granitic rocks to 150 ppm in some diabase. Similarly, the contents of chromium and nickel are highest (10,000 and 2,000 ppm, respectively) in the feldspathic peridotite and lowest in the granitic rocks. Thus, these metals are present in amounts that are normal and expectable for the kinds of rocks in which they are found, and although some metal values in table 1 seem large, they do not suggest the presence of economic concentrations of metals.

The analyses of stream-sediment samples likewise reflect the differences in rock types that are drained by the various streams (table 2). Of the 407 samples of stream sediments, 29 contain more than 6 ppm cxHM, and nearly all of these were collected north of the North Popo Agie River. Many of these 29 samples, which are arbitrarily considered to be anomalous in cxHM, were derived from the more mafic rocks — quartz diorite, diabase, and feldspathic peridotite. The highest cxHM value, 17 ppm (sample 219), was obtained from near Washakie Lake, from a stream draining mostly feldspathic peridotite. Numerous samples that are weakly anomalous in cxHM values are from sites west of Grave Lake, from a terrane dominantly of quartz diorite. Other anomalous samples are from streams that drain diabase, amphibolite, and migmatite in the vicinity of Baptiste Lake.

Even though the dominant rock in the drainage where anomalous samples were collected accounts for most of the anomalous cxHM values, it does not account for all of them; thus, other possibilities were considered. The order in which the samples were collected and analyzed could perhaps bias the results, for the proportion of samples that are anomalous (>6 ppm cxHM) in each batch analyzed decreased as the field season progressed. Analytical error was checked by making replicate analyses on splits of samples that initially yielded cxHM values greater than 6 ppm. A different analyst and different laboratory were used, but systematic differences could not be detected. The decrease in waterflow as the summer progressed could involve changes in water chemistry that could in turn affect the amount of metals adsorbed on the detritus. Seemingly, however, as the contribution of runoff from melting snow decreased and the amount from ground water increased through the summer, values would rise during the summer. Another source of high cxHM values is litter left by campers. Sample 114 collected below Smith Lake could conceivably have derived its cxHM content of 14 ppm from such contamination. Nevertheless, a few samples gave slightly anomalous cxHM values where no mineralization was found and where no other source for the metals is known.

The pan concentrates differ widely in composition, owing to the varying degree to which the heavy minerals were concentrated in the pan. None of these samples gave analyses (table 3) that indicate the presence of mineral deposits. Petrographic examination of the heavy minerals in the pan concentrates showed that the only minerals present were the ones known to be present in the rocks upstream. Every sample contained epidote, zircon, hornblende, magnetite, limonite, apatite, biotite, quartz, and feldspar.

Samples of altered rocks, fault breccia, and gouge were analyzed because, of all rocks in the area, these were considered most likely to contain unusually high metal values. They are, however, as barren as the fresh rock (table 1). The only rocks that might be considered mineralized are the small sparse quartz veins arranged sporadically along the faults and elsewhere. These veins contain (in addition to the quartz), epidote, chlorite, feldspar, magnetite, and hematite. Pyrite was found in one vein, but no other sulfide minerals were found in these veins. The altered rocks on Wind River Peak offer no clue that mineralizing solutions containing valuable metals passed through them.

Sample 104 (table 1) of porphyritic quartz monzonite contains 50 ppm molybdenum. It is the only sample analyzed that contains more than a trace of molybdenum. The sample, collected about 1½ miles west of Cook Lake, consists of a pink granite phase of the Popo Agie batholith from near the contact with a body of hornblende quartz diorite. No evidence of mineralization or alteration was seen at the outcrop, nor was any seen in the hand specimen. The sample is not considered to denote a deposit of any economic significance.

GEIGER-COUNTER SURVEY

Because of the presence of uranium claims in the southeastern part of the area and the extensive uranium exploration that has been carried on in Wyoming, a Geiger-counter traverse was made over most of the main trails. Background ranged from 0.01 to 0.03 mr/hr (milliroentgens per hour). Certain areas that contain large outcrops of granitic rocks showed a slightly higher background. Two narrow dikes of dark-gray diorite, whose relation to the mapped rock units is uncertain, are associated with pegmatite;

they gave readings of several times background. One 6-inch-wide diorite dike about 1,000 feet northwest of Atlantic Lake, in T. 31 N., R. 102 W., gave a reading of 0.07 mr/hr. A chip sample across this dike assayed 0.007 percent U_3O_8. The other dike, about 8 inches wide, at the northwest end of Roaring Fork Mountain, also in T. 31 N., R. 102 W., gave a reading of 0.06 mr/hr and assayed 0.005 percent U_3O_8. (These sample localities are not shown on plate 2.)

At a point about one-half mile east of Washakie Pass, T. 33 N., R. 104 W., a pegmatite dike was found to contain a few small crystals of a radioactive black mineral, possibly allanite. Allanite was also found in pegmatite south of Cathedral Lake. The scarcity of the mineral did not encourage further investigation.

QUARTZ VEINS

Two quartz-hematite veins cut quartz diorite in the southern part of the area; one is on the ridge one-fourth mile east of Atlantic Peak, and the other is one-fourth mile west of Upper Silas Lake. They are anastomosing vein zones, each about 8 feet thick, that trend N. 10° W. Scattered feldspar in the quartz suggests that the veins may be related to the ubiquitous pegmatites. Field observations and spectrographic analysis of samples 517 and 553 (table 1) indicate that the veins have no economic potential.

Two narrow quartz veins were found on the southern slope of an unnamed peak about halfway between Mount Chauvenet and Bears Ears Mountain. About 4 feet apart and parallel, the veins strike N. 65° W. and dip steeply southwest. They appear to be structurally associated, but their composition indicates emplacement under different conditions. The one to the north is nearly pure white quartz and about 1 foot thick, and the other, about 6 inches thick, is rusty quartz with pyrite. A 6-inch channel sample across the latter assayed a trace of gold and no silver. These veins and their sample locality are not shown on plates 1 and 2.

MINING CLAIMS AND MINERAL LEASING

According to Bureau of Land Management records, the Popo Agie area contains no patented mining claims nor any oil and gas leases. Fremont and Sublette County records show that within the past 15 years, three groups of mining claims have been located partly within the area studied.

Townsend Creek, T. 31 N., R. 101 W.

In 1957, 55 mining claims were located, presumably for uranium, in the Townsend Creek drainage (claim group 1, pl. 2); Townsend Creek is a tributary of the Middle Popo Agie River.

Most of the claimed area is covered by thick soil composed largely of grus that has been weathered from the underlying rocks. Although no detailed geologic maps were made of the area, scattered outcrops of granitic rocks indicate that the claims probably are underlain at shallow depth by such rock. A Geiger-counter traverse of the claimed area revealed no radiation that might signify a potential of radioactive minerals. Outcrops are slightly more radioactive than the soil, presumably because the trace amounts of uranium, thorium, and potassium, elements which are common constituents of granitic rocks, have been leached out of the soil. The higher radioactivity of bedrock may have been interpreted by the claim locators as indicating the presence of a significant quantity of radioactive minerals. There has been no production from the claims, and the only excavation in the vicinity is a borrow pit near the east-central boundary of the group that furnished material for nearby road construction. Current affidavits of annual labor had not been filed as of 1970.

Roaring Fork, T. 32 N., R. 101 W.

In late 1969 and early 1970, a group of 68 mining claims was recorded as having been located between the Middle Popo Agie River and Roaring Fork Creek, mostly in secs. 29, 30, 31, and 32, T. 32 N., R. 101 W. (claim group 2, pl. 2). The claims presumably were located for uranium. Outcrops in the area indicate that the claims are underlain by granitic rocks cut by pegmatite dikes. In the northern part of the claim group, bedrock is exposed in bold knobs, whereas in the southern and eastern parts it underlies flat areas and open meadows that have resulted from alluviation behind glacial moraines. Claim posts and location notices were found in the meadow in the northwest corner of sec. 33, near a weather station. Other claim posts and location notices were found in the open park in south-central sec. 29. Evidence of shallow drilling, seemingly entirely in alluvium, was found at both localities. No significant radioactivity was detected in the drill cuttings, and no other evidence of prospecting was found. A traverse of the claims with a Geiger counter showed a background of 0.02 to 0.03 mr/hr on the alluvium and about two to three times this on the bedrock. This difference of background radiation between alluvium and bedrock may have led the locators to believe they had discovered radioactive minerals. At certain localities on the claims near the base of the larger bedrock outcrops, the "mass effect" of these large masses of granitic rocks also may have caused unusually high readings of radioactivity.

Big Sandy Mountain, T. 32 N., R. 103 W.

In 1963 a group of 253 mining claims was recorded in the Fremont and Sublette County records as having been located in the general vicinity of Big Sandy Mountain, Schiestler Peak, and War Bonnet Peak, approximately as indicated by claim group 3 on plate 2. These claims extend from an area covered by older claims. Although mostly in the adjoining Bridger Wilderness, about 100 of the claims apparently extend into the Popo Agie Primitive Area. These are the only mining claims known to have been located in the primitive area. These locations may have been triggered by exploration activity at a molybdenum deposit about 3 miles west of the Continental Divide in the vicinity of Schiestler Peak, in the Bridger Wilderness.

Molybdenum was discovered at the Schiestler Peak locality about 1940, and several claims were staked at that time. A few tons of high-grade molybdenum ore reportedly were packed out of the area on horseback, although no record of this shipment was found. In 1956 the American Molybdenum Corp. located 67 claims, all within the Bridger Wilderness. Work by American Molybdenum was concentrated on the west side of the ridge that extends south from Schiestler Peak. This locality contains a number of pits and trenches, several camp buildings, and several pieces of uninstalled milling machinery. The operation is served by about 8 miles of road that is closed to vehicular travel by all but the claimants.

At several places in the Schiestler Peak area the granitic country rock contains streaks and pockets of molybdenite, molybdite, and copper minerals, but none were found within 2 miles of the Popo Agie Primitive Area during this investigation. Examination of the claimed area in the Popo Agie Primitive Area found neither workings, nor claim monuments, nor evidence of molybdenum mineralization. No affidavits of annual labor had been filed as of 1970. The Schiestler Peak discovery has not been explored or developed to the extent necessary to determine its economic significance.

REFERENCES CITED

Baker, C. L., 1946, Geology of the northwestern Wind River Mountains, Wyoming: Geol. Soc. America Bull., v. 57, no. 6, p. 565–596.

Barrus, R. B., 1968, The bedrock geology of southeastern Alpine Lake quadrangle, Wind River Mountains, Wyoming: Washington (State) Univ. unpub. M.S. thesis, 46 p.

Bassett, W. A., and Giletti, B. J., 1963, Precambrian ages in the Wind River Mountains, Wyoming: Geol. Soc. America Bull., v. 74, no. 2, p. 209–212.

Bayley, R. W., 1963, A preliminary report on the Precambrian iron deposits near Atlantic City, Wyoming: U.S. Geol. Survey Bull. 1142–C, 23 p.

———1965a, Geologic map of the Miners Delight quadrangle, Fremont County, Wyoming: U.S. Geol. Survey Geol. Quad. Map GQ–460.

———1965b, Geologic map of the Louis Lake quadrangle, Fremont County, Wyoming: U.S. Geol. Survey Geol. Quad. Map GQ–461.

Condie, K. C., Leech, A. P., and Baadsgaard, H., 1969, Potassium-argon ages of Precambrian mafic dikes in Wyoming: Geol. Soc. America Bull., v. 80, no. 5, p. 899–906.

Gilluly, James, 1933, Replacement origin of the albite granite near Sparta, Oregon: U.S. Geol. Survey Prof. Paper 175–C, p. 65–81.

Granger, H. C., McKay, E. J., Mattick, R. E., Patten, L. L., and MacIlroy, Paul, 1971, Mineral resources of the Glacier primitive area, Wyoming: U.S. Geol. Survey Bull. 1319–F, 113 p.

Hodge, D. S., and Worl, R. G., 1965, Multiple metamorphic episodes in Precambrian rocks near South Pass City, Wyoming: Wyoming Univ., Contr. Geology, v. 4, no. 2, p. 51–57.

Keefer, W. R., 1965, Stratigraphy and geologic history of the uppermost Cretaceous, Paleocene, and lower Eocene rocks in the Wind River Basin, Wyoming: U.S. Geol. Survey Prof. Paper 495–A, 77 p.

Love, J. D., 1970, Cenozoic geology of the Granite Mountains area, central Wyoming: U.S. Geol. Survey Prof. Paper 495–C, 154 p.

Naylor, R. S., Steiger, R. H., and Wasserburg, G. J., 1968, U–Th–Pb and Rb–Sr systematics in a 2.7×10^9-yr. plutonic complex [abs.]: EOS (Am. Geophys. Union Trans.), v. 49, no. 1, p. 347–348.

Oftedahl, Christoffer, 1953, Petrologic reconnaissance in the pre-Cambrian of the western part of the Wind River Mountains, Wyoming: Norsk Geol. Tidsskr., v. 32, pt. 1, p. 1–17.

Parker, R. B., 1962, Precambrian agmatites of the Wind River Range, Wyoming: Wyoming Univ., Contr. Geology, v. 1, no. 1, p. 13–19.

Perry, Kenneth, Jr., 1965, High-grade regional metamorphism of Precambrian gneisses and associated rocks, Paradise Basin quadrangle, Wind River Mountains, Wyoming: Yale Univ. Ph. D. thesis.

Richmond, G. M., 1945, Geology and oil possibilities at the northwest end of the Wind River Mountains, Sublette County, Wyoming: U.S. Geol. Survey Oil and Gas Inv. Prelim. Map 31 [repr. 1957].

St. John, Orestes, 1883, Report on the geology of the Wind River district: U.S. Geol. and Geog. Survey Terr. (Hayden), 12th Ann. Rept., pt. 1, p. 173–269.

Spencer, A. C., 1916, The Atlantic gold district and the North Laramie Mountains, Fremont, Converse, and Albany counties, Wyoming: U.S. Geol. Survey Bull. 626, 85 p.

Vacquier, Victor, Steenland, N. C., Henderson, R. G., and Zietz, Isidore, 1951, Interpretation of aeromagnetic maps: Geol. Soc. America Mem. 47, 151 p.

Worl, R. G., 1963, Superposed deformations in Precambrian rocks near South Pass, Wyoming: Wyoming Univ., Contr. Geology, v. 2, no. 2, p. 109–116.

———1968, Taconite in the Wind River Mountains, Sublette County, Wyoming: Wyoming Geol. Survey Prelim. Rept. 10, 15 p.

TABLES 1–3

TABLE 1. — *Semiquantitative spectrographic analyses*

[See plate 2 for sample localities. Number in parentheses below element symbol indicates limit; N, element was looked for but not found. Also looked for but not found, except as

Semiquantitative spectrographic analyses

Sample	(percent)				(ppm)							
	Fe (.05)	Mg (.02)	Ca (.05)	Ti (.001)	Mn (10)	Ba (10)	Be (1)	Co (5)	Cr (5)	Cu (2)	La (20)	Nb (10)
021	5.0	L	0.15	0.03	50	1,500	N	N	7	N	L	N
023	3	.5	1	.2	200	1,500	L	7	L	L	150	L
024	3	.5	1.5	.3	150	1,500	L	N	L	5	100	L
036	2	.5	1	.2	100	1,500	L	L	L	L	20	L
040	7	1.5	3	.3	1,000	500	L	15	15	L	30	L
045	7	1.5	3	.3	700	700	L	10	7	L	50	L
059	10	.2	.7	.1	100	200	L	10	L	10	50	10
078	2	.3	1.5	.15	150	700	L	7	5	L	50	N
079	2	.3	1	.1	150	700	L	L	L	L	20	L
103	5	1.5	2	.3	500	700	L	20	70	10	150	L
104[3/]	1.5	.3	.7	.3	150	300	N	N	L	7	70	N
105	.2	.07	2	.02	30	150	1.0	N	L	7	N	N
112	10	1.5	3	.3	700	1,000	L	15	30	5	150	L
113	3	.3	1.5	.15	100	1,000	L	N	L	N	100	N
119	15	3	7	.5	1,500	100	N	50	200	50	N	L
124	10	1.5	5	.5	700	3,000	N	20	70	L	300	L
125	3	.7	2	.3	300	700	L	10	50	L	200	L
126	.3	.15	1	.02	70	300	L	L	L	L	L	N
134	10	.5	3	.5	500	300	L	50	15	7	150	10
137	7	1.5	5	.5	500	700	L	20	150	10	150	10
138	3	1	1.5	.3	300	1,500	L	7	20	L	200	L
152	3	.7	2	.2	300	700	L	7	L	N	70	L
153	15	7	2	.15	1,500	70	L	70	10,000	15	N	10
157	10	5	7	.7	1,000	1,000	N	20	300	20	150	10
158	.7	.05	.3	.1	100	500	L	N	5	7	N	L
159	2	.7	1	.2	200	1,000	L	10	L	L	70	L
163	10	7	2	.15	1,000	150	N	70	10,000	10	N	10
165	1	.1	L	.03	30	30	L	N	7	5	70	N
166	2	.5	.1	.15	300	200	L	5	L	L	150	N
167	2	.5	1	.2	100	1,500	L	L	L	L	200	L
168	1.5	.7	.5	.2	150	1,000	L	7	L	10	100	L
173	3	.5	1.5	.15	200	1,000	L	5	L	N	70	N
175	3	2	.7	.5	200	L	N	5	30	L	100	L
176	1.5	1	.5	.3	200	100	L	L	7	L	150	L
177	15	5	5	.5	1,000	50	L	30	150	100	L	L
179	5	.7	2	.2	500	500	L	10	10	L	200	L
185	2	.7	1	.15	300	70	N	N	15	L	70	N
187	7	3	5	.3	1,000	700	N	30	300	15	30	L
189	3	.7	1.5	.2	500	2,000	L	7	20	7	70	L
190[4/]	.3	.7	7	.5	300	1,000	L	N	N	5	N	N
191	10	3	7	.3	700	200	N	30	200	15	N	L
192	1.5	.15	5	.5	100	100	L	N	L	L	L	L
193	7	2	3	.3	700	700	N	15	15	L	30	L
213	7	3	.5	.5	200	L	N	10	L	L	20	L
215	15	7	3	.15	1,000	70	L	70	10,000	15	L	L
222	7	7	2	.1	700	100	L	70	5,000	7	N	L
235	10	3	7	.5	1,000	100	N	50	200	150	N	10
250	.2	.2	L	.03	70	100	L	N	L	7	N	N
264	1.5	.5	.5	.02	150	50	L	7	L	L	70	N
270	1	.7	.15	.03	100	20	L	L	L	L	N	N
272	15	5	7	.5	1,500	500	N	30	300	L	20	10
278	3	.7	1	.3	200	500	L	5	15	L	50	L
284	10	.3	.15	.1	100	20	L	L	L	L	N	15
292	.7	.3	.3	.02	150	150	L	L	N	L	N	N
305	2	.7	1.5	.2	200	700	L	L	15	L	50	L

1/ Section, township (2 south, and 31, 32, and 33 north), and range (4, 101, 102, 103, and 104 west).

2/ Samples referred to merely as "altered" are from "altered" zones on Wind River Peak that are shown on plate 1 and described in text.

of rock samples from the Popo Agie area, Wyoming

sensitivity of method. Symbols: L, element was detected but in an amount below the sensitivity noted: Ag, As, Au, B, Bi, Cd, Mo, Sb, Sn, W, and Zn]

Semiquantitative spectrographic analyses--Continued

Sample	Ni (2)	Pb (10)	Sc (5)	(ppm) Sr (50)	V (10)	Y (5)	Zr (10)	Location[1/] S	T	R	Rock type[2/]
021	10	15	N	200	70	N	N	12	32	103	Porphyritic quartz monzonite.
023	5	15	5	200	50	L	150	7	32	102	Fine-grained quartz monzonite.
024	10	20	L	300	50	30	150	6	32	102	Quartz diorite.
036	10	15	L	300	20	10	20	28	33	103	Porphyritic quartz monzonite.
040	15	10	10	300	70	20	50	18	33	102	Quartz diorite.
045	20	15	15	1,000	50	20	30	13	33	103	Do.
059	L	10	N	150	30	N	15	18	32	102	Quartz from pegmatite.
078	7	15	5	100	L	N	70	5	33	104	Migmatite.
079	5	20	N	300	L	15	15	1	33	104	Quartz diorite.
103	50	15	15	700	100	30	50	28	33	103	Do.
104	7	15	L	150	20	20	10	28	33	103	Porphyritic quartz monzonite.
105	7	15	N	700	L	N	50	28	33	103	Pegmatite.
112	20	15	15	500	100	20	50	22	33	103	Quartz diorite.
113	L	10	N	200	30	L	70	22	33	103	Porphyritic quartz monzonite.
119	70	L	50	100	200	30	50	29	33	102	Diabase.
124	50	15	10	1,500	100	30	150	18	32	102	Fault gouge.
125	20	20	10	500	50	20	200	8	32	102	Porphyritic quartz monzonite.
126	L	15	L	200	20	L	20	8	32	102	Fine-grained quartz monzonite.
134	30	30	30	1,000	50	20	150	14	32	103	Pyrite and epidote.
137	30	15	15	1,500	70	30	150	2	32	104	Epidotized quartz monzonite.
138	10	20	15	300	50	30	150	2	32	104	Porphyritic quartz monzonite.
152	10	15	15	500	50	15	50	19	33	102	Quartz diorite.
153	1,500	10	15	L	70	15	30	7	33	103	Feldspathic peridotite.
157	100	10	20	700	100	30	150	4	33	103	Quartz diorite.
158	10	10	N	N	10	N	20	6	33	103	Quartz-epidote vein.
159	10	20	L	500	30	10	30	6	33	103	Porphyritic quartz monzonite.
163	2,000	15	15	N	70	10	30	18	33	103	Feldspathic peridotite.
165	7	L	L	N	15	N	100	19	33	103	Quartz-hematite veinlets.
166	15	10	7	N	30	N	150	19	33	103	Sericitized quartz monzonite.
167	7	10	5	300	30	30	150	19	33	103	Fault gouge.
168	10	L	5	300	30	10	150	30	33	103	Do.
173	10	20	5	500	30	20	70	11	33	104	Porphyritic quartz monzonite.
175	20	N	5	L	30	20	200	21	2	4	Fault gouge.
176	10	10	7	L	30	10	70	21	2	4	Do.
177	50	10	20	150	150	30	70	5	33	104	Diabase.
179	15	15	10	300	50	20	150	5	33	104	Quartz diorite.
185	15	L	5	N	30	N	50	10	33	104	Altered rock from fault.
187	100	20	20	700	100	15	10	15	33	104	Quartz diorite.
189	15	30	7	500	30	15	70	16	33	103	Do.
190	L	10	L	700	20	20	150	26	32	103	Altered rock.
191	70	L	50	200	150	20	50	26	32	103	Diabase.
192	N	N	L	200	20	10	300	27	32	103	Altered rock.
193	20	20	15	700	100	30	50	35	32	103	Quartz diorite.
213	30	L	10	N	100	20	200	18	33	103	Fault gouge.
215	1,500	L	15	L	70	N	70	23	33	104	Feldspathic peridotite.
222	1,500	15	15	N	50	10	20	22	33	104	Do.
235	70	L	30	L	150	30	70	20	2	4	Diabase.
250	L	N	5	N	L	L	15	23	32	103	Quartz from fault.
264	10	N	N	200	20	N	70	13	31	103	Do.
270	10	L	N	L	15	N	20	12	31	103	Albite-quartz rock.
272	150	15	30	300	200	30	100	1	31	103	Paragneiss.
278	10	10	10	200	30	20	150	31	32	102	Fault breccia.
284	5	N	L	N	100	15	100	22	31	102	Quartz-magnetite vein.
292	L	15	N	200	20	10	20	12	31	102	Quartz diorite.
305	10	10	L	500	20	15	70	22	32	103	Porphyritic quartz monzonite.

3/ Contains 50 ppm Mo.

4/ Contains 20 ppm B.

TABLE 1. — *Semiquantitative spectrographic analyses of rock*

Semiquantitative spectrographic analyses

	(percent)				(ppm)							
Sample	Fe (.05)	Mg (.02)	Ca (.05)	Ti (.001)	Mn (10)	Ba (10)	Be (1)	Co (5)	Cr (5)	Cu (2)	La (20)	Nb (10)
318	3.0	0.7	1.5	0.3	200	1,000	N	N	L	L	50	L
320	3	.5	1.5	.13	700	1,500	L	7	L	30	50	L
332	5	1.5	1.5	.2	500	500	L	15	200	10	20	L
345	7	1.5	2	.5	300	1,500	N	10	10	5	100	L
351	1.5	.5	1.5	.15	200	1,000	L	5	N	10	100	L
368	5	1	2	.3	500	1,000	L	10	10	L	70	L
369	5	1	2	.3	300	1,000	L	10	15	15	70	L
377 5/	2	.5	1.5	.3	200	1,500	N	N	L	15	100	L
378	3	.7	1.5	.2	200	1,500	L	7	7	7	70	L
379	7	1	3	.3	700	700	L	15	7	L	30	L
386	3	.5	1	.2	300	1,500	N	L	L	30	150	N
387	1.5	.2	1	.15	150	1,500	L	N	L	15	30	L
389	2	.3	1.5	.1	150	700	L	5	L	10	50	L
390	2	.03	L	.003	20	L	N	N	L	15	N	N
392	10	.2	1	.2	500	500	L	5	L	50	N	10
393	10	2	.5	.2	500	700	L	15	7	5	150	L
394	5	1	3	.3	500	1,500	L	7	L	7	100	L
395	7	1	3	.5	700	300	N	10	10	5	30	L
402	1	.07	.7	.02	100	700	3.0	N	L	L	L	N
403	1.5	.15	1	.15	200	700	1	N	L	15	100	L
410	3	.7	2	.2	500	1,000	L	10	L	10	50	L
418	15	7	5	.3	1,500	1,000	N	30	1,500	70	70	L
419 6/	2	.3	.5	.15	150	1,000	L	5	10	20	70	L
420	1.5	.1	.2	.05	100	200	1.5	L	N	15	N	L
421	2	.7	1	.2	200	700	1	20	20	7	150	10
422	3	1	1.5	.3	200	300	L	30	50	10	30	10
423	1	.07	.3	.05	70	500	1.5	N	N	20	N	L
426	5	.02	.2	1	2,000	200	N	15	20	15	N	500
462	3	1	3	.5	1,000	1,000	1	10	7	10	50	L
463	3	1	2	.3	500	700	L	15	10	L	50	L
465	7	1	2	.5	300	1,500	L	10	7	10	150	L
466	2	.5	1.5	.15	150	1,000	L	L	L	L	70	L
469	2	.5	.7	.2	100	500	L	10	15	5	100	10
472	2	.5	7	.15	100	70	1	N	7	L	100	N
509	2	.3	1	.15	200	700	1.5	N	L	70	70	L
517	1.5	.2	.2	.07	50	20	L	N	L	7	30	N
518	3	.7	1.5	.2	200	700	L	5	5	L	70	L
519	5	1	2	.3	700	1,000	L	10	5	15	70	L
520	3	.5	1	.15	300	1,500	1	L	L	10	100	L
552	3	1	.5	.15	500	L	N	7	L	30	L	L
553 6/	20	.5	L	.03	100	100	L	N	10	L	N	10
554	3	.7	2	.3	300	1,500	L	7	L	15	150	N
557	5	.1	2	.1	200	1,000	L	N	7	20	N	L
559	2	3	7	.2	200	50	N	L	150	L	150	N
560	1.5	.05	7	.3	30	70	1.5	N	100	L	150	L
561	2	1	5	.3	70	150	L	N	L	L	200	L
571	5	.2	.7	.1	150	700	1.5	15	N	50	N	L

5/ Contains 0.7 ppm Ag.

samples from the Popo Agie area, Wyoming — Continued

Semiquantitative spectrographic analyses--Continued

Sample	Ni (2)	Pb (10)	Sc (5)	Sr (50)	V (10)	Y (5)	Zr (10)	Location[1] S T R	Rock type[2]
	(ppm)								
318	5	15	N	300	30	L	70	30 32 102	Porphyritic quartz monzonite.
320	7	20	5	150	30	N	100	29 32 102	Fine-grained quartz monzonite.
332	70	20	20	300	100	10	50	6 31 102	Paragneiss.
345	10	15	10	200	70	30	150	14 31 102	Fine-grained quartz monzonite.
351	7	20	5	500	30	10	150	24 32 103	Porphyritic quartz monzonite.
368	15	20	10	700	70	30	150	15 31 103	Quartz diorite.
369	10	10	10	500	70	30	200	11 31 103	Fine-grained quartz monzonite.
377	7	30	N	200	20	N	100	18 31 102	Do.
378	10	20	N	700	70	10	50	8 31 102	Quartz monzonite.
379	15	20	10	700	70	20	150	8 31 102	Quartz diorite.
386	10	30	L	300	10	15	150	17 31 102	Fine-grained quartz monzonite.
387	L	15	N	200	10	N	70	17 31 102	Quartz monzonite.
389	7	15	L	300	L	L	50	21 31 102	Do.
390	7	N	N	N	20	N	N	21 31 102	Quartz-hematite vein.
392	5	70	7	200	150	L	150	15 31 102	Quartz monzonite.
393	30	10	7	N	70	20	150	23 31 102	Fault breccia.
394	7	20	5	200	70	30	150	23 31 102	Fine-grained quartz monzonite.
395	15	15	15	500	70	20	150	23 31 102	Quartz diorite.
402	L	30	L	200	L	L	50	17 31 101	Quartz monzonite.
403	5	50	N	150	L	10	100	7 31 101	Do.
410	7	15	L	500	50	10	70	20 31 101	Quartz diorite.
418	300	20	30	150	100	70	100	18 33 102	Do.
419	20	15	10	200	20	20	200	8 33 102	Porphyritic quartz monzonite.
420	10	10	L	100	10	N	10	8 33 102	Pegmatite.
421	20	20	5	500	50	L	100	13 33 103	Quartz diorite.
422	20	15	7	700	70	20	200	20 33 102	Do.
423	20	70	N	200	L	N	10	5 33 102	Pegmatite.
426	10	150	50	L	50	100	50	4 31 101	Do.
462	7	30	15	700	70	30	100	8 31 101	Quartz diorite.
463	20	20	15	700	70	20	100	5 31 101	Do.
465	15	30	10	150	50	30	150	24 33 102	Fine-grained quartz monzonite.
466	10	15	L	300	20	10	70	2 31 102	Quartz monzonite.
469	20	10	7	300	50	20	200	3 32 103	Porphyritic quartz monzonite.
472	7	N	N	700	20	L	30	26 32 103	Altered rock.
509	5	50	L	200	15	L	150	35 31 102	Quartz monzonite.
517	7	L	N	N	20	N	10	34 31 102	Quartz-hematite vein.
518	7	15	N	500	50	N	100	2 30 102	Quartz diorite.
519	10	15	10	500	50	10	100	3 31 102	Quartz monzonite.
520	10	20	L	300	15	10	150	29 32 102	Fine-grained quartz monzonite.
552	10	N	5	N	30	N	70	25 31 102	Fault breccia.
553	5	10	5	N	300	N	20	30 31 101	Quartz-hematite vein.
554	5	15	7	150	30	20	150	26 31 102	Fine-grained quartz monzonite.
557	7	20	N	200	50	L	50	26 31 102	Quartz monzonite.
559	30	10	15	1,000	20	30	70	27 32 103	Altered rock.
560	L	10	15	1,000	70	30	200	27 32 103	Do.
561	15	15	L	700	30	15	150	21 32 103	Do.
571	70	200	N	300	15	N	50	8 32 102	Porphyritic quartz monzonite.

6/ Contains 10 ppm B.

TABLE 2.—*Analyses of stream-sediment*

[See plate 2 for sample localities. Number in parentheses below element symbol indicates limit; N, element was looked for but not found; cxHM, citrate-soluble heavy-metals test; noted: Ag, As, Au, B, Bi, Cd, Mo, Sb, Sn, W, and Zn]

Semiquantitative spectrographic analyses

	(percent)				(ppm)						
Sample	Fe (.05)	Mg (.02)	Ca (.05)	Ti (.001)	Mn (10)	Ba (10)	Be (1)	Co (5)	Cr (5)	Cu (2)	La (20)
001	1.5	0.3	1.5	0.5	300	500	1.0	7	15	7	50
002	3	.5	2	.7	500	500	1	10	30	7	150
003	5	.7	1.5	.7	700	500	1	15	50	7	70
004	7	.7	1.5	.7	700	300	1	15	100	15	150
005	5	.7	1.5	.7	500	300	1	20	50	10	150
006	3	.7	1	.7	500	300	1	20	50	10	100
007	3	.5	.7	.3	200	300	1	10	50	10	150
009	5	.7	1.5	.7	700	500	1	15	50	15	150
010	2	.3	1	.5	150	700	1.5	5	30	5	100
011	3	.3	1	.3	500	300	1	10	30	7	150
012	3	.3	1.5	.5	300	500	1	10	20	L	70
013	.5	.1	.3	.05	70	70	1	N	10	7	50
014	1	.15	.7	.3	300	200	1	L	10	5	70
015	3	.5	1	.5	300	300	1	10	50	7	70
016	3	.5	1	.5	300	300	1	15	50	7	70
017	3	.3	1	.5	200	300	1	10	30	5	70
018	3	.3	.7	.3	200	300	1	10	30	5	150
020	3	.3	.7	.5	300	300	1.5	5	20	5	150
022	3	.5	.7	.5	200	300	1	10	20	5	70
025	3	.3	.7	.5	300	300	1.5	10	20	10	70
026	3	.3	.7	.5	150	300	1	5	20	L	70
027	.5	.1	.3	.07	50	150	L	N	10	5	70
028	1.5	.3	.7	.3	150	300	1	7	15	5	70
029	3	.5	1.5	.5	500	500	1	10	30	7	100
030	3	.5	1	.5	300	300	1	10	50	7	100
031	3	.7	2	.5	300	500	1	15	30	7	70
032	7	.5	1.5	.7	300	300	1	15	30	7	70
033	3	.7	1.5	.3	500	300	1	10	20	10	70
034	3	.5	1	.5	300	300	1	10	20	5	70
035	5	.5	1.5	.7	500	300	1.5	10	20	7	150
037	3	.5	.7	.5	200	300	1	10	30	15	100
038	3	.7	1	.5	300	500	1	15	20	15	150
039	3	.3	1	.5	200	300	1	10	30	7	100
041	3	.7	2	.5	700	700	L	15	50	7	70
042	3	.7	1.5	.3	700	500	L	15	50	7	100
043	3	.7	1.5	.3	700	500	L	15	50	10	70
044	5	1	2	.3	1,000	500	L	15	50	10	100
046[2]	3	.5	1	.3	500	700	L	15	50	10	100
047	3	.7	2	.3	700	500	L	10	50	7	70
048	3	.7	2	.3	700	700	L	15	50	5	70
049	3	.7	1.5	.3	700	500	L	15	50	10	70
050	5	.7	1.5	.3	500	500	L	15	50	7	70
051	5	.7	1	.5	300	300	1	20	30	10	100
052	3	.5	1	.5	300	300	1	15	30	7	100
053	3	.7	1.5	.7	300	500	1	20	30	10	100
054	3	.7	1	.5	300	300	1	20	30	10	100
055	5	.7	1.5	.5	300	300	1	20	30	10	150
056	3	.3	.7	.3	200	500	1	10	15	5	50
057	3	.3	.7	.5	200	300	1	10	15	5	100
058	3	.3	1	.5	700	300	1	15	30	5	100
060	3	.5	1	.3	300	700	L	15	30	L	100
061	.7	.1	.2	.07	150	150	L	L	15	5	70
062	2	.3	.7	.3	150	500	1	7	30	5	70
063	1	.5	.3	.15	200	300	1	5	10	5	100
073	3	.7	2	.3	300	700	L	10	50	15	100

1/ Section, township(2 south, and 31, 32, and 33 north), and range (3, 4, 101, 102, 103, and 104 west).

samples, Popo Agie area, Wyoming

sensitivity of method. Symbols: L, element was detected but in an amount below the sensitivity dash leaders (..............), element was not looked for. Also looked for but not found, except as

Sample	Semiquantitative spectrographic analyses--Continued (ppm)								Chemical analyses (ppm)	Location[1]		
	Nb (10)	Ni (2)	Pb (10)	Sc (5)	Sr (50)	V (10)	Y (5)	Zr (10)	cxHM (1)	S	T	R
001	L	10	15	10	300	50	20	300	10	29	33	102
002	L	15	30	15	300	100	50	500	3	30	33	102
003	L	20	30	20	300	70	50	700	1	30	33	102
004	L	15	50	30	150	150	70	1,000	5	22	33	103
005	10	20	50	30	200	100	70	300	3	16	33	103
006	10	30	70	15	200	70	50	300	8	16	33	103
007	L	15	50	10	100	70	30	300	8	15	33	103
009	L	15	20	30	300	100	50	1,000	3	35	33	103
010	L	7	15	10	300	70	15	1,000	5	35	33	103
011	L	10	70	10	150	70	50	700	10	36	33	103
012	L	L	20	20	300	70	30	1,000	3	31	33	102
013	L	L	15	L	N	20	10	300	8	22	33	103
014	L	L	10	7	150	70	30	700	5	23	33	103
015	10	10	15	15	300	70	30	700	5	26	33	103
016	L	15	20	15	200	70	30	500	5	25	33	103
017	L	10	20	10	200	70	20	500	1	30	33	102
018	L	10	15	10	150	70	30	300	8	28	33	102
020	L	L	15	10	150	70	30	1,000	8	18	32	102
022	L	15	15	10	200	70	20	150	1	7	32	102
025	L	10	15	10	300	70	30	1,000	1	1	32	103
026	L	5	10	10	150	70	20	1,000	1	12	32	103
027	L	5	15	L	150	20	15	50	5	14	32	103
028	L	15	10	10	200	50	20	300	5	11	32	103
029	L	30	20	15	300	70	30	300	1	3	32	103
030	L	20	50	10	300	70	20	500	5	8	32	103
031	L	30	20	15	300	70	30	300	5	4	32	103
032	10	10	10	15	300	100	30	1,000	1	5	32	103
033	L	15	30	7	200	70	20	200	8	2	32	104
034	L	10	10	7	200	70	20	150	1	2	32	104
035	L	15	15	15	300	70	20	1,000	5	6	32	103
037	L	20	15	10	300	70	15	300	3	6	32	103
038	L	15	70	15	300	70	30	150	3	8	32	103
039	L	15	15	15	300	70	20	700	3	8	32	103
041	L	15	20	15	700	70	50	200	N	18	33	102
042	L	20	30	10	500	70	30	200	N	18	33	102
043	L	20	30	15	500	70	30	500	1	13	33	103
044	10	20	20	15	300	70	30	200	N	13	33	103
046	L	15	20	10	300	70	20	200	5	13	33	103
047	L	15	20	10	300	50	20	300	N	8	33	102
048	L	20	20	15	500	70	30	300	N	11	33	102
049	10	20	30	15	200	70	50	300	N	17	33	103
050	L	15	20	10	300	70	30	200	N	17	33	103
051	L	30	30	15	300	70	20	150	1	22	33	103
052	L	20	30	10	300	50	20	200	8	22	33	103
053	L	30	20	15	300	70	50	300	3	21	33	103
054	L	30	20	10	300	70	20	200	1	21	33	103
055	L	20	30	15	300	70	50	300	5	22	33	103
056	N	7	20	10	300	50	15	700	5	31	33	102
057	L	5	15	10	300	50	20	700	3	31	33	102
058	L	10	20	10	300	70	20	700	13	35	33	103
060	L	20	15	10	300	50	15	200	5	12	32	103
061	N	L	L	L	100	20	10	70	3	13	32	103
062	L	15	20	10	300	30	15	200	3	11	32	103
063	L	5	20	7	200	20	15	150	14	11	32	103
073	10	20	20	15	500	70	30	150	1	17	33	102

2/ Contains 15 ppm B.

TABLE 2. — *Analyses of stream-sediment*

Semiquantitative spectrographic analyses

Sample	(percent)				(ppm)						
	Fe (.05)	Mg (.02)	Ca (.05)	Ti (.001)	Mn (10)	Ba (10)	Be (1)	Co (5)	Cr (5)	Ca (2)	La (20)
074	5.0	1.5	2.0	0.3	700	700	L	15	700	10	100
075	3	.7	1.5	.3	300	700	L	7	200	7	50
076	5	1	3	.5	700	500	L	15	100	15	200
077	5	1.5	2	.3	500	700	L	15	70	15	70
085	3	.7	2	.5	500	700	L	10	15	7	50
086	3	.7	2	.3	700	700	1.0	10	20	10	70
087	5	.7	2	.5	500	700	L	10	20	5	70
088	3	.7	2	.3	700	700	L	7	15	10	70
089	3	.7	1.5	.3	700	700	1	10	20	15	70
090	3	.7	2	.3	500	700	L	7	20	10	100
091	3	.7	2	.5	700	700	L	5	15	5	70
092	5	1	2	.5	500	700	1	10	30	20	100
093	5	1	2	.3	500	700	L	10	50	7	70
094	5	1	2	.5	500	700	L	10	50	5	70
095	5	.7	3	.7	500	700	L	10	30	7	70
096	3	.7	2	.3	300	500	1	10	30	10	70
097	5	.7	2	.3	500	500	L	15	50	15	70
098	5	1	3	.5	700	700	L	10	30	20	50
099	3	.7	2	.3	700	700	L	10	30	70	70
100[3/]	5	1	2	.3	500	700	L	15	30	20	50
102	3	.5	.7	.3	200	300	1	15	30	10	100
107	5	.7	1	.5	300	500	L	20	100	7	100
108	2	.3	.7	.3	150	300	L	10	15	L	100
109	2	.3	.5	.3	150	300	1	5	10	L	150
110	3	.5	1.5	.5	300	300	1.5	10	15	15	70
111	3	.7	1	.7	300	300	1	15	30	7	100
114	.7	.15	5	.2	300	150	1	N	15	5	70
115	3	.5	1.5	.7	500	300	1	10	30	15	200
116	3	.5	1.5	.5	300	700	1	15	20	10	70
117	3	.5	1	.5	300	500	1	10	30	10	70
118	5	.5	1.5	.5	700	300	1	15	20	15	100
120	3	.3	1	.5	300	500	1.5	10	15	20	70
121	5	.5	1	.5	300	300	1.5	15	30	15	100
122	3	.5	1.5	.5	500	300	1	10	20	7	70
123	3	.3	1	.5	500	300	1	10	20	7	70
130	1	.2	.7	.5	200	300	1	5	10	7	50
131	3	.7	1	.5	500	300	1.5	15	30	7	70
132	5	.7	1.5	.7	700	300	1	15	30	7	100
133	3	.5	1	.5	500	500	1	15	20	7	70
135	3	.5	1	.7	500	300	1	15	30	7	100
136	1	.3	.7	.3	150	300	L	5	20	5	70
139	3	.5	1	.7	300	300	1	15	20	15	100
140	1.5	.3	.7	.5	200	300	1	7	15	20	70
141	3	.3	.5	.5	200	300	1	7	20	5	50
142	5	.7	1.5	.7	500	500	1.5	15	20	20	100
143	5	.7	1	.5	700	300	1	15	20	15	100
144	3	.3	1.5	.5	700	500	1	10	15	20	70
147	3	.5	1.5	.5	500	700	L	10	30	10	100
148	3	1	2	.3	700	500	1	15	70	15	100
150	3	.7	2	.3	700	500	L	15	150	15	70
151	3	.7	2	.3	500	500	L	15	30	15	70
154	3	.7	2	.3	700	500	L	10	70	7	70
155	3	.7	1.5	.3	700	300	L	15	70	15	70
156	5	2	3	.3	700	500	L	20	1,000	10	100
160	2	.7	1	.3	500	500	L	10	50	15	70
161	3	.7	1.5	.3	500	500	N	15	70	15	70
162	2	.7	1.5	.15	500	500	1	10	70	10	70
164[3/]	3	.7	1.5	.3	700	500	L	15	70	10	150
169	3	.7	1.5	.3	500	500	L	10	30	7	70
170	3	.7	1.5	.2	300	500	L	15	50	15	150

3/ Contains 10 ppm B.

samples, Popo Agie area, Wyoming — Continued

Sample	Semiquantitative spectrographic analyses--Continued (ppm) Nb (10)	Ni (2)	Pb (10)	Sc (5)	Sr (50)	V (10)	Y (5)	Zr (10)	Chemical analyses (ppm) cxHM (1)	Location[1] S	T	R
074	10	70	20	15	500	70	30	150	3	5	33	103
075	L	30	20	10	500	30	15	200	5	5	33	103
076	15	30	30	15	500	100	50	150	8	23	33	104
077	L	50	50	10	500	70	20	100	10	23	33	104
085	L	15	20	15	700	70	20	200	3	25	32	103
086	L	15	30	10	500	70	20	100	3	25	32	103
087	L	15	20	15	500	70	20	150	3	25	32	103
088	L	15	20	15	300	50	20	200	N	24	32	103
089	L	20	20	10	300	70	20	150	N	24	32	103
090	L	15	15	15	500	70	30	150	N	21	32	102
091	L	15	30	10	300	50	20	150	N	21	32	102
092	10	15	30	15	300	70	50	500	1	20	32	102
093	L	20	30	15	500	70	30	300	N	10	31	103
094	L	20	20	15	500	100	30	700	N	11	31	103
095	10	20	20	20	700	70	30	300	N	11	31	103
096	L	15	50	15	500	70	30	200	3	11	31	103
097	L	20	50	15	300	70	30	500	5	18	31	102
098	L	20	20	15	500	70	20	500	N	7	31	102
099	L	20	20	15	300	50	30	300	N	7	31	102
100	L	30	30	15	300	70	30	200	5	7	31	102
102	L	20	30	10	300	50	15	200	13	27	33	103
107	L	50	20	15	300	70	50	300	3	27	33	103
108	L	15	15	10	300	30	20	300	3	31	33	102
109	N	7	15	7	150	50	20	300	5	36	33	103
110	L	7	20	15	300	70	20	1,000	1	35	33	103
111	L	20	15	15	300	50	20	700	1	35	33	103
114	L	5	10	5	L	30	30	100	14	26	33	103
115	L	20	30	10	300	70	30	700	1	30	33	102
116	L	7	30	15	300	70	30	700	1	28	33	102
117	L	20	20	10	300	70	30	300	5	29	33	102
118	L	10	30	10	200	70	30	700	10	29	33	102
120	L	10	20	10	300	50	20	700	3	6	32	102
121	L	10	20	15	300	70	30	700	5	6	32	102
122	L	10	15	10	300	70	20	500	5	13	32	103
123	L	15	30	10	300	50	20	500	3	12	32	103
130	L	L	30	5	200	30	10	700	1	15	32	103
131	L	15	50	15	300	70	20	500	5	15	32	103
132	L	15	30	20	300	100	30	700	5	10	32	103
133	L	15	20	15	300	70	20	300	1	12	32	103
135	L	15	20	20	200	70	30	700	1	3	32	103
136	L	7	15	7	150	50	15	150	5	6	32	103
139	L	15	20	15	300	70	30	700	3	1	32	104
140	L	7	10	10	200	50	20	700	5	1	32	104
141	L	10	15	10	200	50	10	700	1	6	32	103
142	L	10	10	20	300	70	30	1,000	1	11	32	103
143	L	10	20	15	300	70	30	700	5	1	32	103
144	L	7	15	10	300	70	20	500	5	1	32	103
147	L	20	15	10	500	50	30	700	N	4	33	102
148	L	20	10	10	500	70	30	300	8	5	33	102
150	L	20	15	15	500	70	30	300	5	20	33	102
151	L	15	15	15	500	50	20	150	N	20	33	102
154	L	15	20	10	500	50	30	70	N	5	33	103
155	L	20	20	10	300	50	30	200	8	5	33	103
156	L	70	20	20	700	100	50	300	N	24	2	4
160	L	15	15	10	300	50	20	70	1	8	33	103
161	L	15	30	10	500	70	20	150	3	8	33	103
162	L	20	15	7	500	30	20	150	3	7	33	103
164	10	30	30	15	500	70	30	200	1	18	33	103
169	L	15	15	10	500	70	30	150	3	19	33	103
170	L	15	30	10	500	50	20	100	8	30	33	103

TABLE 2. — *Analyses of stream-sediment*

Semiquantitative spectrographic analyses

Sample	(percent) Fe (.05)	Mg (.02)	Ca (.05)	Ti (.001)	(ppm) Mn (10)	Ba (10)	Be (1)	Co (5)	Cr (5)	Cu (2)	La (20)
171	3.0	1.0	1.5	0.3	200	700	L	15	70	10	100
172	3	1.5	2	.3	500	500	L	15	100	7	100
174	3	1	2	.3	700	300	L	15	100	10	70
178	3	.7	1	.3	300	300	L	10	50	15	70
180	3	1	2	.3	500	700	L	15	50	7	70
181	3	1	2	.3	500	700	L	15	70	10	70
182	3	.7	2	.2	500	700	L	15	70	7	70
183	3	.7	1.5	.2	500	300	1.0	10	20	L	70
184	3	1	2	.3	500	700	L	15	70	10	150
186	5	1.5	3	.5	700	1,000	L	20	70	15	150
188	3	1	1.5	.3	700	500	L	15	100	15	70
194	7	1.5	3	.3	700	700	L	20	70	15	100
195	5	1	2	.3	500	700	L	15	50	15	70
196	3	1	3	.3	500	500	L	15	30	15	70
197	5	1	2	.3	500	500	L	15	30	15	70
198	5	1	2	.3	700	500	L	15	50	10	70
199	2	.7	1.5	.3	300	300	1	10	20	15	100
201	3	1	1.5	.3	700	700	L	15	100	7	100
202	3	2	2	.5	700	500	L	15	500	5	70
203[2/]	5	2	2	.5	700	500	L	15	300	20	70
204	3	1.5	2	.5	700	500	L	15	70	7	50
205	3	1	2	.3	700	200	N	10	100	10	50
206	3	1	2	.3	500	700	N	15	300	5	100
208	3	1	2	.5	500	300	2	15	200	7	100
209	5	1.5	2	.7	700	700	L	15	1,000	7	100
210	3	1	2	.3	500	700	L	15	300	5	150
211	3	2	1.5	.3	300	500	L	15	300	5	150
212	2	.7	2	.3	300	700	L	10	70	5	150
214[3/]	2	.5	1	.3	200	300	L	7	70	7	70
216[3/]	3	1	1.5	.3	500	300	1	20	700	10	100
217	7	5	2	.3	700	500	L	30	3,000	10	50
218	2	.7	1	.2	200	200	L	10	700	7	50
219	2	.7	1	.2	300	200	1	10	150	10	70
220	3	.7	1.5	.3	300	700	L	15	150	7	70
221	3	1	2	.3	700	700	L	15	300	10	70
223	1	.2	1	.3	150	200	L	L	15	7	100
224	2	.5	1	.3	300	500	L	10	200	5	100
225	3	1	1.5	.3	500	500	L	15	150	10	200
226	3	.7	1.5	.3	500	300	L	15	70	10	300
228	3	1	2	.3	700	500	L	10	70	7	70
229	3	1	1.5	.3	700	500	L	15	70	10	70
230	3	.7	1.5	.5	500	300	L	10	70	20	70
231	3	1	2	.3	1,000	300	L	15	70	20	70
232	5	2	2	.3	1,000	200	L	15	300	10	50
233	3	.5	1.5	.2	500	200	L	7	7	5	70
234	2	.5	1.5	.3	300	150	L	10	15	7	70
236	5	1	2	.5	300	300	N	15	70	10	70
237	3	.7	2	.3	700	200	L	15	70	15	70
238	3	.7	1.5	.3	300	300	L	10	15	50	70
239	3	1	1	.3	500	300	L	10	30	50	100
240	7	1	2	.5	700	500	L	15	70	20	100
242	5	.7	2	.3	500	700	L	15	70	10	70
244	3	1	2	.3	500	700	L	15	70	10	100
246	3	.7	1	.2	700	500	L	15	50	10	100
247	3	.7	1	.3	200	500	L	10	50	20	150
249	1.5	.2	.2	.07	150	100	1	N	15	10	50
251	3	1	1.5	.3	500	700	1	10	30	15	70
252	2	.7	1	.3	300	300	L	10	200	7	70
253	3	1	1.5	.3	1,000	700	L	15	150	10	100
254	3	1	1.5	.5	500	500	L	15	70	10	100

samples, Popo Agie area, Wyoming — Continued

Sample	Nb (10)	Ni (2)	Pb (10)	Sc (5)	Sr (50)	V (10)	Y (5)	Zr (10)	Chemical analyses (ppm) cxHM (1)	Location[1/] S	T	R
	Semiquantitative spectrographic analyses--Continued											
171	L	20	20	10	500	50	20	100	1	30	33	103
172	L	50	20	15	700	70	20	200	3	11	33	104
174	L	30	20	15	300	70	20	150	N	11	33	104
178	L	20	20	10	200	50	20	150	8	5	33	104
180	L	20	30	10	500	70	15	100	10	4	33	104
181	L	20	30	15	300	70	30	150	5	4	33	104
182	L	20	30	10	300	50	30	150	8	4	33	104
183	L	20	20	10	300	50	30	150	N	4	33	104
184	L	30	30	15	300	70	30	150	8	4	33	104
186	10	30	20	15	700	70	30	200	5	15	33	104
188	L	30	30	15	300	70	30	200	8	3	33	104
194	L	30	30	20	500	100	30	300	3	35	32	103
195	L	20	50	15	300	70	30	150	N	35	32	103
196	L	15	30	15	500	70	30	150	N	35	32	103
197	L	20	50	15	300	70	30	150	N	36	32	103
198	10	20	30	15	500	70	30	100	1	25	32	103
199	L	15	50	10	300	50	20	100	1	25	32	103
201	10	30	20	15	500	70	20	100	N	5	33	103
202	L	70	15	15	500	70	20	150	N	5	33	103
203	L	70	50	15	300	70	20	150	3	23	2	4
204	L	20	20	15	300	70	30	700	3	6	33	103
205	L	20	20	10	300	70	20	200	1	6	33	103
206	L	30	20	10	500	70	30	300	N	1	33	104
208	L	30	20	10	300	50	70	150	N	12	33	104
209	L	50	20	15	500	70	20	70	1	12	33	104
210	L	30	20	15	500	70	30	100	N	13	33	104
211	10	30	20	15	300	100	30	150	1	12	33	104
212	L	20	15	10	700	50	30	150	N	13	33	104
214	L	20	15	10	150	50	20	150	1	13	33	104
216	10	150	30	15	150	70	30	150	13	23	33	104
217	L	500	10	20	200	70	20	100	N	22	33	104
218	L	50	20	10	150	50	15	100	1	23	33	104
219	L	50	30	10	200	50	20	70	17	23	33	104
220	L	30	30	15	500	70	20	150	3	14	33	104
221	L	30	30	15	500	70	20	150	3	13	33	104
223	L	7	20	7	300	30	20	100	3	11	33	104
224	L	20	15	10	300	50	30	150	N	12	33	104
225	10	30	30	15	200	70	30	150	N	21	2	4
226	L	30	30	15	200	70	30	150	3	1	33	104
228	L	20	30	10	300	70	20	150	N	5	33	104
229	L	30	30	15	300	70	20	150	3	19	2	4
230	L	15	20	10	200	70	20	300	1	19	2	4
231	L	30	30	10	300	70	20	100	5	3	33	104
232	L	70	20	10	300	70	20	200	3	3	33	104
233	L	15	20	7	500	50	20	30	N	11	33	104
234	L	10	15	7	300	50	30	100	3	1	33	104
236	L	20	20	15	500	70	30	200	5	3	33	104
237	L	30	30	15	300	100	30	150	5	2	33	104
238	L	15	20	10	200	50	20	150	1	11	33	103
239	L	15	50	15	200	70	30	150	1	11	33	103
240	L	20	20	15	300	70	30	700	N	11	33	103
242	L	20	20	15	500	70	30	300	1	12	33	103
244	L	20	20	15	500	70	30	150	3	12	33	103
246	L	20	20	10	150	70	30	150	1	6	33	102
247	L	20	20	15	200	70	30	300	1	5	33	102
249	N	L	20	L	L	20	30	50	1	14	32	103
251	L	20	30	10	500	70	20	150	N	19	33	103
252	L	30	20	10	300	70	20	150	5	13	33	104
253	L	30	30	7	300	70	20	200	8	13	33	104
254	10	30	30	15	500	70	30	150	5	14	33	104

TABLE 2. — *Analyses of stream-sediment*

Semiquantitative spectrographic analyses

Sample	(percent) Fe (.05)	Mg (.02)	Ca (.05)	Ti (.001)	(ppm) Mn (10)	Ba (10)	Be (1)	Co (5)	Cr (5)	Cu (2)	La (20)
255	3.0	1.0	1.5	0.3	300	700	L	10	50	7	100
256	3	1	2	.3	700	700	L	10	70	7	70
257	5	.7	2	.3	500	700	L	10	20	30	70
258	3	.7	1.5	.3	700	500	1.0	10	50	15	50
259	5	.7	1.5	.3	500	500	L	10	30	10	70
260[3/]	5	1	2	.5	700	700	L	15	50	15	70
261	7	1	3	.3	700	700	L	10	70	7	50
262	5	1	2	.5	700	700	L	15	50	20	70
263	5	1.5	2	.5	700	700	L	15	70	15	70
265	5	1	2	.3	700	700	1	20	70	30	100
266	5	1.5	2	.3	700	700	1	15	50	30	100
267	5	1	2	.5	700	700	L	15	50	15	70
268	5	1	2	.5	500	700	L	10	50	15	70
269	3	1	1.5	.3	500	500	L	15	70	30	50
271	5	.7	2	.3	500	500	L	10	50	15	30
273	3	.7	2	.5	500	700	L	15	50	30	70
274	3	.7	2	.3	300	500	L	15	50	15	30
275	3	.7	2	.3	500	500	L	10	20	20	30
276	3	1	2	.3	500	700	1	15	50	20	70
277	5	1	2	.5	500	500	L	15	30	10	50
279	3	.7	1.5	.3	300	500	L	10	10	30	50
280	3	.7	1.5	.2	300	700	L	10	15	10	150
281	3	.7	1	.3	200	500	L	7	50	10	70
282	3	.7	1	.2	700	300	L	10	30	15	100
283	1.5	.2	.7	.2	150	300	1	N	10	L	100
285	3	.7	2	.3	500	300	L	10	15	7	50
286	.7	.15	.3	.07	70	100	L	N	7	5	70
287	1	.2	.3	.15	100	200	L	N	15	7	70
288	1.5	.5	.7	.2	300	150	L	L	15	10	70
290	3	.7	1.5	.3	700	500	L	10	50	10	100
291	1.5	.3	1	.15	200	300	1.5	5	15	7	150
293	5	1	2	.3	700	700	1	15	70	7	70
294	3	.7	2	.3	500	500	L	10	20	7	30
295	3	.7	1.5	.3	500	500	L	10	30	7	70
296	5	1	1.5	.3	500	700	L	15	30	7	50
297	5	.7	2	.3	700	700	L	15	50	7	70
298	3	1	2	.3	700	700	1	15	50	10	150
299	3	.7	2	.3	700	500	L	10	30	10	100
300	2	.5	1	.3	500	200	1	L	15	7	150
302	3	1	2	.3	500	700	L	10	70	10	70
303	3	.7	1.5	.3	500	700	L	7	50	15	100
304	3	.7	1.5	.3	500	1,000	L	7	50	7	70
306	3	1	1.5	.3	700	700	L	10	50	7	70
307[3/]	2	.7	.7	.3	150	500	L	L	50	5	100
308	.5	.15	.5	.15	70	300	L	N	15	5	100
309	7	2	2	.5	700	700	L	15	70	15	100
310	7	1	3	.7	700	1,000	L	15	70	10	100
311	7	1	2	.5	700	1,000	L	15	50	7	100
312	7	1	2	.7	700	700	L	15	50	10	150
313	5	1	3	.5	700	700	1	10	30	10	70
314	3	1	1.5	.3	700	700	L	7	20	7	70
315	3	.7	1	.2	200	300	L	5	10	5	100
316	5	.7	2	.3	700	300	L	10	15	5	100
317	1	.15	.3	.1	150	150	L	N	7	10	150
319	1.5	.5	.5	.2	300	300	1	N	20	10	100
322	3	1.5	1	.3	500	700	L	10	50	7	70
323	3	.5	1	.2	700	500	1	10	20	10	70
325	5	1.5	2	.3	700	700	L	15	70	7	70
326	5	.7	2	.3	500	700	L	10	50	7	70
327	5	1	2	.3	700	500	1	10	30	7	70

samples, Popo Agie area, Wyoming — Continued

Sample	Semiquantitative spectrographic analyses--Continued (ppm) Nb (10)	Ni (2)	Pb (10)	Sc (5)	Sr (50)	V (10)	Y (5)	Zr (10)	Chemical analyses (ppm) cxHM (1)	Location[1] S T R
255	L	20	20	10	500	50	15	100	3	5 33 104
256	L	20	20	10	300	50	30	150	5	5 33 104
257	L	15	20	15	500	70	20	200	1	25 32 103
258	L	15	30	15	500	70	20	500	1	24 32 103
259	L	20	20	10	300	70	20	150	1	24 32 103
260	L	20	50	15	500	70	20	200	1	24 32 103
261	L	20	20	15	700	70	30	200	1	14 31 103
262	L	20	30	15	700	70	30	200	1	14 31 103
263	10	30	20	15	700	70	30	200	3	14 31 103
265	L	30	50	15	700	100	30	300	1	18 31 102
266	L	20	30	20	700	70	30	200	1	18 31 102
267	L	20	50	15	300	70	30	500	N	18 31 102
268	L	20	15	15	500	70	20	150	1	7 31 102
269	L	20	20	10	200	70	20	150	1	7 31 102
271	L	20	20	15	300	70	20	300	1	1 31 103
273	10	30	30	15	500	50	30	300	1	6 31 102
274	L	20	20	15	300	50	30	150	3	36 32 103
275	L	15	15	15	500	30	30	150	3	31 32 102
276	L	20	20	15	700	50	30	150	1	31 32 102
277	L	20	20	20	500	50	30	150	1	31 32 102
279	L	15	20	10	300	50	20	150	N	27 31 102
280	L	15	20	10	500	30	20	100	N	22 31 102
281	L	15	20	10	200	50	20	150	N	22 31 102
282	L	20	50	10	200	50	20	150	N	22 31 102
283	L	5	15	10	100	50	20	150	N	22 31 102
285	L	15	50	20	500	50	20	150	N	16 31 102
286	N	L	15	L	L	20	20	50	N	15 31 102
287	L	5	30	5	100	30	20	100	N	15 31 102
288	L	5	15	7	150	50	20	150	N	15 31 102
290	L	15	30	15	200	70	30	150	N	11 31 102
291	L	10	15	7	100	50	30	100	N	12 31 102
293	10	30	30	15	500	70	30	150	N	14 31 102
294	10	15	30	15	300	70	30	200	N	14 31 102
295	10	15	20	15	300	70	20	150	N	14 31 102
296	L	20	20	15	500	70	20	150	1	14 31 102
297	L	15	30	15	500	100	30	100	3	13 31 102
298	10	20	30	15	500	100	30	150	1	13 31 102
299	L	15	20	15	300	70	30	150	1	7 31 101
300	L	7	20	7	100	70	50	150	1	12 31 102
302	L	50	30	15	300	70	20	200	1	23 32 103
303	L	15	50	10	200	70	30	200	N	23 32 103
304	L	15	30	10	700	50	20	150	N	22 32 103
306	L	20	30	15	200	70	20	300	1	23 32 103
307	L	15	10	10	150	70	20	200	N	23 32 103
308	L	L	10	5	100	30	20	70	1	24 32 103
309	10	30	20	15	500	100	50	500	1	23 32 103
310	15	20	30	20	700	150	70	500	1	20 32 102
311	10	15	30	15	700	100	50	200	1	20 32 102
312	15	15	30	20	300	100	70	1,000	1	20 32 102
313	15	20	20	20	700	100	30	500	1	19 32 102
314	L	15	50	10	500	70	20	200	1	19 32 102
315	L	10	30	7	200	70	30	100	N	31 32 102
316	L	15	20	15	300	70	30	150	N	31 32 102
317	L	L	10	L	100	20	30	50	N	30 32 102
319	L	5	10	5	150	50	30	100	N	29 32 102
322	L	20	20	10	300	70	20	150	3	33 32 102
323	L	15	30	7	300	50	20	150	1	12 31 103
325	L	30	20	15	700	70	30	150	1	7 31 102
326	L	20	20	15	500	70	30	200	1	32 32 102
327	L	20	20	15	500	70	30	300	3	32 32 102

TABLE 2. — *Analyses of stream-sediment*

Semiquantitative spectrographic analyses

Sample	(percent) Fe (.05)	Mg (.02)	Ca (.05)	Ti (.001)	(ppm) Mn (10)	Ba (10)	Be (1)	Co (5)	Cr (5)	Cu (2)	La (20)
328	5.0	1.0	3.0	0.3	700	1,000	L	7	50	15	100
331	5	1	2	.5	500	500	1.0	10	70	7	150
333	5	.7	2	.5	700	700	L	10	50	10	70
334	5	1	2	.3	700	1,000	L	15	50	15	70
336	3	.7	2	.3	700	1,000	L	10	30	15	70
337	3	.7	1.5	.3	700	700	L	10	50	10	100
338	3	.7	2	.2	300	700	L	7	15	L	50
339	5	.7	2	.3	500	700	L	7	20	10	70
341	5	.7	2	.3	500	500	L	7	50	15	70
342[3]	3	1	2	.3	300	700	L	10	50	15	100
343	3	.7	2	.3	500	700	L	L	30	10	70
344	1.5	.3	1	.15	150	700	L	N	20	7	70
346	5	.7	2	.3	500	700	L	7	20	10	70
347	3	.7	1.5	.2	300	300	1	10	30	5	70
348	2	.5	1.5	.3	300	300	L	L	20	7	100
349	2	.7	2	.3	200	700	1.5	L	20	7	150
350	3	.7	2	.2	500	500	1	10	20	5	150
352	5	1	2	.3	500	700	L	15	70	7	70
353	5	.7	1.5	.3	700	700	L	10	50	15	100
354	1.5	.5	1	.15	300	200	L	L	20	7	150
355	5	1.5	3	.5	700	700	L	15	50	7	100
356[3]	3	1	1.5	.2	700	500	L	15	50	10	70
357	5	1	2	.3	500	500	L	15	50	10	70
358	5	1	2	.5	500	700	1	15	50	7	70
359	3	1	2	.3	500	700	1	15	50	10	70
360	3	.7	1.5	.3	500	500	L	10	30	10	100
361	3	1	2	.3	500	700	L	10	30	7	70
362	3	.7	2	.3	500	700	L	10	20	7	50
363	5	1.5	2	.5	700	700	L	15	50	7	70
364	5	1	2	.5	500	500	L	10	30	5	70
365[3]	5	1.5	2	.3	700	700	L	10	50	15	50
366[2]	3	.7	1	.3	200	300	L	7	30	5	50
367	3	.7	1	.3	500	500	L	10	50	7	70
370	5	1	1.5	.3	300	500	L	10	30	10	70
371	2	.5	1	.2	150	200	1	L	15	7	70
372	3	1	2	.5	500	700	L	10	50	7	70
373	3	.7	1.5	.3	300	500	L	7	30	7	50
374	3	.7	1.5	.3	500	500	L	10	30	7	70
375[3]	2	.5	1	.3	700	300	1	7	30	10	50
376	3	.7	3	.3	500	500	L	10	50	L	50
380	3	.7	1.5	.3	300	500	L	10	50	5	70
381	3	.7	1.5	.3	200	500	L	7	30	5	20
382	3	.7	1.5	.3	700	500	L	10	70	5	70
383	3	.7	1.5	.3	300	300	L	5	30	7	50
384	5	.7	1.5	.5	300	500	L	7	30	7	50
385[3]	5	1	2	.5	700	700	L	15	70	10	70
388[3]	5	.7	1.5	.3	500	500	1	10	50	10	50
391[3]	2	.5	.7	.15	200	200	1	L	30	7	70
396	3	.7	1.5	.3	300	500	L	5	50	5	20
397	3	.5	1.5	.3	500	500	L	5	20	5	50
398	3	.7	2	.3	300	700	1	7	30	7	70
399	5	.7	2	.5	700	500	L	L	20	10	50
400	3	.7	1.5	.3	200	700	L	7	30	10	70
405	7	.7	2	.3	700	500	L	10	30	15	70
407	3	.7	1.5	.2	700	500	L	10	15	15	70
409	3	1	1.5	.3	500	500	L	15	30	15	70
411	2	.7	1.5	.3	200	700	L	10	50	5	70
412	2	.5	2	.3	200	300	L	L	20	5	70
413	.3	.07	.3	.05	70	70	L	N	7	5	L
414	3	.7	2	.5	700	700	L	10	70	7	70

samples, Popo Agie area, Wyoming — Continued

Sample	Semiquantitative spectrographic analyses--Continued (ppm) Nb (10)	Ni (2)	Pb (10)	Sc (5)	Sr (50)	V (10)	Y (5)	Zr (10)	Chemical analyses (ppm) cxHM (1)	Location[1/] S	T	R
328	L	20	20	15	700	50	30	200	1	32	32	102
331	L	30	20	20	500	70	50	500	1	7	31	102
333	L	20	20	15	500	70	30	200	3	5	31	102
334	L	20	30	15	700	70	20	150	3	5	31	102
336	L	15	20	10	500	50	30	500	3	5	31	102
337	L	20	20	10	200	70	20	150	3	4	31	102
338	L	15	20	10	500	30	20	100	1	9	31	102
339	L	20	30	10	300	50	20	300	1	9	31	102
341	10	20	50	10	300	70	30	200	5	9	31	102
342	L	20	70	10	200	70	30	150	1	22	31	102
343	L	20	30	15	500	50	15	70	N	22	31	102
344	L	L	15	5	100	20	20	500	N	15	31	102
346	L	15	30	15	500	70	20	200	3	14	31	102
347	L	15	15	15	200	50	30	200	1	12	31	102
348	L	10	10	5	150	30	30	150	1	12	31	102
349	L	15	20	10	300	30	70	150	1	12	31	102
350	L	15	15	10	300	50	30	100	3	33	32	102
352	L	20	20	15	500	70	20	200	N	19	32	102
353	L	20	20	15	300	70	30	200	N	19	32	102
354	L	10	15	7	300	20	30	100	3	19	32	102
355	L	30	50	30	700	70	70	500	1	2	31	103
356	L	15	20	15	200	50	30	150	1	2	31	103
357	L	20	50	15	300	70	30	150	1	2	31	103
358	L	15	20	15	300	70	30	300	N	3	31	103
359	L	20	50	15	300	70	20	150	3	2	31	103
360	L	20	30	15	300	70	30	200	5	2	31	103
361	L	20	30	15	500	50	30	300	5	11	31	103
362	L	15	30	15	500	70	30	150	N	11	31	103
363	L	20	50	15	500	100	20	500	3	11	31	103
364	L	15	15	15	500	70	10	500	3	11	31	103
365	L	15	30	15	500	70	30	500	1	11	31	103
366	L	15	15	7	150	50	20	200	1	12	31	103
367	L	20	20	10	200	50	20	150	3	1	31	103
370	L	20	30	10	300	70	20	150	5	3	31	103
371	L	L	20	L	100	30	20	150	3	11	31	103
372	10	30	30	15	700	70	30	500	1	11	31	103
373	L	20	15	10	300	50	20	200	3	12	31	103
374	L	20	15	15	300	50	20	150	3	12	31	103
375	L	10	15	5	L	50	20	150	5	12	31	103
376	L	15	20	15	500	70	30	700	8	6	31	102
380	L	20	20	10	200	70	20	150	10	8	31	102
381	L	15	20	7	300	50	15	100	3	9	31	102
382	L	15	20	15	300	50	70	150	3	9	31	102
383	L	15	20	10	200	50	20	150	3	9	31	102
384	L	15	20	5	300	50	20	150	1	10	31	102
385	L	20	20	15	300	70	20	200	3	17	31	102
388	L	15	50	10	300	50	20	150	3	20	31	102
391	L	5	20	5	100	30	20	70	3	16	31	102
396	N	10	20	10	300	50	15	150	3	4	31	102
397	L	10	20	10	300	50	15	200	3	34	32	102
398	L	20	30	10	300	50	30	500	1	34	32	102
399	L	10	15	15	500	70	20	500	5	34	32	102
400	L	20	20	10	500	50	10	150	5	26	32	102
405	L	10	30	15	500	100	30	300	3	7	31	101
407	L	15	20	10	300	50	30	100	1	7	31	101
409	L	20	30	15	500	70	30	150	1	7	31	101
411	L	20	20	15	300	70	30	300	1	4	32	102
412	L	7	10	15	300	70	30	500	5	4	32	102
413	N	L	10	L	100	15	10	30	3	13	32	102
414	L	10	30	15	500	70	30	300	3	21	32	102

TABLE 2. — *Analyses of stream-sediment*

Semiquantitative spectrographic analyses

Sample	(percent)				(ppm)						
	Fe (.05)	Mg (.02)	Ca (.05)	Ti (.001)	Mn (10)	Ba (10)	Be (1)	Co (5)	Cr (5)	Cu (2)	La (20)
415	7.0	0.7	1.5	0.3	500	700	1.0	10	70	5	100
416	2	.3	1.5	.3	700	300	L	15	30	7	100
417	1.5	.3	1.5	.3	200	500	1	7	20	L	70
425	2	.5	1.5	.5	300	700	1	10	50	5	70
428	3	.7	1.5	.3	500	700	1	15	70	7	70
429	5	.7	2	.3	300	500	L	15	70	10	100
451[3/]	1.5	.5	1	.2	100	300	L	L	20	10	100
452	3	.7	1.5	.3	500	300	L	10	20	20	70
453	3	1	2	.3	500	300	L	10	30	20	100
454	3	1	2	.3	700	700	L	10	30	15	100
455	3	.7	1.5	.3	700	500	L	7	30	20	70
456	2	.7	1.5	.2	200	700	1	7	30	7	70
457	2	.5	2	.3	300	500	L	7	15	20	100
458	3	.7	2	.3	500	500	1	10	20	20	100
459	3	.7	2	.5	300	500	N	7	20	20	70
460	2	1	2	.3	500	300	L	10	10	10	50
461	3	.7	2	.3	700	500	L	15	20	15	70
464	3	1	2	.3	700	500	L	15	30	20	70
467	5	1	3	.3	500	500	L	10	30	20	150
468	3	.7	2	.3	500	300	L	10	30	10	100
470	3	1	2	.3	300	500	L	15	100	5	70
471	3	.07	1	.1	1,000	150	1	7	10	L	70
473	1	.3	1	.15	200	200	1	N	15	7	50
474	5	.5	1.5	.3	300	500	1	10	70	5	50
475[3/]	1.5	.7	1.5	.3	150	700	1	7	70	5	100
501	3	.7	1	.2	500	300	L	10	20	10	70
502	3	.7	2	.3	300	500	L	7	20	15	70
503	2	.5	1.5	.2	500	300	1	7	20	5	150
504	1.5	.3	1	.15	200	300	L	5	15	L	100
505	3	1	2	.3	700	500	L	10	20	15	70
506	5	1	3	.5	500	500	L	10	30	10	70
507	5	1	2	.3	1,000	500	L	15	30	10	70
508	3	.7	1.5	.3	700	500	1	15	30	10	100
510	3	.7	2	.3	300	500	L	7	15	15	70
511	3	.7	2	.5	500	500	L	10	15	10	70
512	3	.7	1.5	.3	300	500	L	10	30	15	70
513	2	.7	1.5	.3	300	500	L	7	30	7	100
514	3	.7	1.5	.2	500	500	1	10	30	10	70
515	3	.7	2	.3	300	300	L	5	15	5	50
516	3	.7	2	.3	300	500	L	5	15	20	70
521[3/]	3	1	1.5	.3	500	500	1	7	30	20	150
523	5	.7	2	.5	500	500	L	10	20	15	70
524[3/]	2	1	1.5	.3	300	700	L	15	100	10	200
525	3	1	2	.3	500	500	N	10	50	10	150
526	2	.5	1	.3	300	500	1	7	30	5	100
527	5	.7	2	.3	500	700	N	10	15	5	50
528	3	.7	1.5	.3	500	700	L	10	50	7	100
529	1.5	.7	1	.15	200	500	1	10	70	5	150
530	5	1	2	.3	500	500	1	10	30	7	100
531	3	.5	1.5	.3	200	700	L	7	30	L	30
532	5	.7	2	.3	700	500	L	15	50	7	150
533	3	.7	2	.3	700	700	L	15	70	5	100
534	3	.7	2	.3	700	500	L	15	20	5	70
535	1.5	.7	2	.3	300	700	L	L	20	7	50
536	2	.7	2	.3	300	500	L	7	20	7	50
537	5	1	2	.2	500	500	L	10	30	L	50
538	2	.7	1.5	.2	200	700	L	10	50	5	100
539	3	.7	2	.3	300	700	L	10	70	5	70
540[3/]	3	1	1.5	.3	500	500	L	15	70	10	100
541	5	2	3	.5	500	500	L	15	70	7	100

samples, Popo Agie area, Wyoming — Continued

Sample	Semiquantitative spectrographic analyses--Continued (ppm)								Chemical analyses (ppm)	Location[1]		
	Nb (10)	Ni (2)	Pb (10)	Sc (5)	Sr (50)	V (10)	Y (5)	Zr (10)	cxHM (1)	S	T	R
415	L	15	30	15	500	100	30	200	N	20	32	102
416	L	15	30	10	200	50	30	200	4	18	32	102
417	L	10	15	10	300	30	30	100	1	18	32	102
425	L	20	20	20	500	70	50	150	---	4	31	101
428	10	30	20	15	300	70	30	300	---	11	31	101
429	L	30	20	20	300	100	30	200	---	11	31	101
451	L	15	15	5	150	50	30	150	3	10	31	102
452	L	15	20	10	300	70	20	150	1	9	31	102
453	L	15	20	15	300	50	30	500	1	9	31	102
454	L	15	30	15	500	70	30	150	2	23	31	102
455	L	15	30	10	300	70	20	70	5	25	31	102
456	L	10	15	10	300	30	15	100	1	25	31	102
457	L	15	20	10	300	30	15	100	1	30	31	101
458	10	15	20	15	700	70	20	150	1	30	31	101
459	L	10	20	10	300	50	30	300	1	30	31	101
460	L	7	15	7	300	30	15	70	1	30	31	101
461	L	15	20	15	300	70	20	150	1	29	31	101
464	L	20	20	15	300	70	30	200	2	6	31	101
467	L	20	15	15	500	70	30	150	1	3	32	103
468	L	15	30	10	200	70	20	300	1	3	32	103
470	10	20	20	20	300	70	50	300	3	14	33	103
471	L	L	15	10	150	30	20	100	4	27	32	102
473	N	L	15	7	100	30	20	70	2	9	32	102
474	L	10	20	15	150	100	30	1,000	3	16	32	102
475	L	20	20	15	300	50	30	200	1	16	32	102
501	L	15	20	10	150	70	20	100	1	18	31	101
502	L	15	20	10	500	70	20	100	1	18	31	101
503	L	15	15	10	150	70	30	100	2	18	31	101
504	L	7	15	7	150	50	20	50	1	18	31	101
505	L	10	20	10	300	30	20	150	1	6	31	101
506	L	15	20	15	500	70	20	100	1	6	31	101
507	10	20	50	15	300	70	30	70	6	34	31	102
508	10	15	50	15	300	100	30	100	6	35	31	102
510	L	15	20	10	300	70	20	100	1	36	31	102
511	L	15	20	10	300	70	20	100	1	36	31	102
512	L	15	30	10	500	70	15	70	1	36	31	102
513	L	15	15	10	500	50	30	100	1	31	31	101
514	L	15	15	10	500	50	30	150	1	31	31	101
515	L	10	15	10	300	30	20	150	2	31	31	101
516	L	15	15	15	500	50	15	150	1	31	31	101
521	L	15	15	10	300	50	30	150	1	28	32	102
523	L	15	20	15	500	70	30	150	2	27	32	102
524	L	30	20	15	200	70	30	200	3	17	2	3
525	L	15	20	15	200	70	50	300	4	21	2	3
526	L	10	15	15	150	50	50	500	1	21	2	3
527	L	15	15	15	500	50	30	200	1	23	32	102
528	L	15	20	10	300	50	20	150	3	26	32	102
529	L	20	20	10	150	50	30	150	1	26	32	102
530	L	20	20	15	500	100	30	200	1	25	32	102
531	L	10	10	15	500	70	20	100	3	24	32	102
532	10	20	15	15	500	70	30	150	2	23	32	102
533	10	20	70	20	700	70	50	200	1	24	32	102
534	L	10	20	10	500	70	30	150	1	23	32	102
535	L	10	15	20	700	50	15	200	2	14	32	103
536	L	5	20	30	500	70	30	500	1	14	32	103
537	L	15	15	15	500	70	20	150	3	15	32	102
538	L	20	20	15	300	50	30	200	1	15	32	102
539	L	15	20	20	700	70	30	700	2	15	32	102
540	10	30	20	20	200	100	50	300	2	10	32	102
541	L	30	20	30	700	100	30	1,000	1	9	32	102

|

TABLE 2. — *Analyses of stream-sediment*

Semiquantitative spectrographic analyses

Sample	(percent) Fe (.05)	Mg (.02)	Ca (.05)	Ti (.001)	(ppm) Mn (10)	Ba (10)	Be (1)	Co (5)	Cr (5)	Cu (2)	La (20)
551[4/]	3.0	0.7	1.5	0.3	500	500	1.0	10	20	20	100
555	3	.7	1.5	.3	300	500	L	10	15	10	70
556	5	.7	1.5	.3	500	500	L	10	10	10	70
558	5	1	2	.5	700	700	L	10	10	15	100
562	3	.7	1.5	.3	700	300	L	7	15	15	70
564	2	.5	1.5	.3	200	700	L	7	10	7	70
566[3/]	3	.7	1.5	.3	500	700	L	10	70	15	100
567	2	.7	1	.2	300	500	L	7	30	5	100
568	10	.7	2	.3	500	500	L	15	200	5	20
569	3	.7	2	.3	300	700	1	15	300	5	100
572	3	.5	1.5	.2	300	500	L	10	50	7	70
573	1	.3	1.5	.1	100	200	1	N	7	7	100
574	3	.5	1.5	.3	300	200	L	10	30	10	100
575	2	.7	1.5	.2	200	300	L	10	50	7	70
576	3	.7	1.5	.3	300	500	N	10	50	7	70

4/ Contains 20 ppm B.

samples, Popo Agie area, Wyoming — Continued

Sample	Semiquantitative spectrographic analyses--Continued (ppm) Nb (10)	Ni (2)	Pb (10)	Sc (5)	Sr (50)	V (10)	Y (5)	Zr (10)	Chemical analyses (ppm) cxHM (1)	Location[1] S	T	R
551	10	15	50	10	300	50	30	300	6	25	31	102
555	L	10	15	7	300	50	15	100	1	26	31	102
556	L	15	30	15	300	70	15	150	3	26	31	102
558	L	15	20	15	500	50	30	150	1	26	31	102
562	L	10	15	10	300	30	15	150	4	27	32	102
564	L	10	15	10	300	50	20	150	2	22	32	102
566	L	15	30	20	500	70	30	500	2	4	32	102
567	L	15	15	10	150	50	20	150	3	4	32	102
568	L	20	20	20	500	150	30	500	2	4	32	102
569	L	15	20	15	500	70	30	700	1	9	32	102
572	L	20	20	10	200	50	20	150	---	7	33	102
573	N	L	L	10	150	15	20	150	---	7	33	102
574	10	20	15	15	200	70	30	200	---	7	33	102
575	L	20	15	10	300	50	20	150	---	7	33	102
576	L	30	20	10	200	50	30	100	---	12	33	103

TABLE 3. — *Semiquantitative spectrographic analyses*

[See plate 2 for sample localities. Number in parentheses below element symbol indicates below the sensitivity limit; N, element was looked for but not found. Also looked for but

Semiquantitative spectrographic analyses

Sample	(percent) Fe (.05)	Mg (.02)	Ca (.05)	Ti (.001)	(ppm) Mn (10)	Ba (10)	Be (1)	Co (5)	Cr (5)	Cu (2)	La (20)
008	10	0.7	2.0	1.0	700	300	L	10	50	10	150
019	20	.7	2	1	700	300	L	15	70	10	70
101	15	1	2	1	700	500	L	15	50	15	100
145	15	1	2	.7	700	500	N	15	100	10	70
146	15	.5	1.5	1	500	150	L	10	100	7	100
149	>20	.5	1.5	.5	500	150	L	15	200	L	70
207	20	1	1.5	>1	1,000	100	L	20	1,000	7	300
243	>20	1	2	.5	700	200	L	20	300	7	150
245	15	1	3	.7	700	500	L	10	100	30	100
248	>20	.5	1.5	1	700	70	L	20	500	20	70
289	15	.7	5	.7	700	300	L	10	70	20	100
321	20	.7	3	1	700	200	L	20	150	15	150
324	>20	.7	3	1	700	100	L	30	500	7	100
329	>20	.7	2	1	700	300	N	20	200	10	300
330	20	1.5	7	>1	1,000	200	L	10	70	15	100
335	20	1.5	5	>1	1,000	300	L	20	150	10	100
340	20	.7	3	1	1,000	300	N	7	50	20	70
401	>20	.7	2	1	700	300	L	20	300	10	100
404	>20	1	5	1	700	200	N	20	300	10	100
406	20	.7	3	1	700	300	L	10	70	15	100
408	>20	1	3	.7	700	300	N	20	150	15	70
424 2/	7	.7	3	1	2,000	200	N	15	100	15	200
427	>20	.2	.7	.2	700	100	N	50	500	L	70
522	>20	.7	2	1	700	70	N	20	300	7	100
563	15	.7	2	.7	700	300	L	10	7	10	70
565	20	.7	5 5	1	700	300	L	15	300	7	150
570	20	.7	3	1	300	300	L	15	300	7	200

1/ Section, township (31, 32, and 33 north), and range (101, 102, and 103 west).

of pan-concentrate samples, Popo Agie area, Wyoming

sensitivity of method. Symbols: >, greater than; L, element was detected but in an amount not found, except as noted: Ag, As, Au, B, Bi, Cd, Mo, Sb, Sn, W, and Zn]

Semiquantitative spectrographic analyses--Continued

Sample	Nb (10) (ppm)	Ni (2)	Pb (10)	Sc (5)	Sr (50)	V (10)	Y (5)	Zr (10)	Location[1/] S T R
008	N	10	20	20	500	70	70	>1,000	31 33 102
019	N	15	15	20	300	100	50	>1,000	32 33 102
101	N	15	20	15	500	70	50	>1,000	30 33 102
145	N	20	15	30	500	70	50	700	17 33 102
146	N	15	20	30	500	70	70	>1,000	4 33 102
149	N	15	15	20	150	150	50	>1,000	5 33 102
207	10	50	15	20	150	200	100	>1,000	12 33 104
243	10	20	15	20	300	300	70	>1,000	12 33 103
245	10	15	20	30	500	100	70	>1,000	12 33 103
248	L	20	10	30	100	300	70	>1,000	11 32 103
289	10	10	15	30	700	150	50	>1,000	10 31 102
321	L	10	15	50	700	200	70	>1,000	33 32 102
324	10	15	15	50	700	300	70	>1,000	7 31 102
329	L	15	20	30	500	300	70	>1,000	32 32 102
330	L	15	15	50	1,000	200	70	>1,000	6 31 102
335	15	15	15	50	700	200	70	>1,000	5 31 102
340	L	10	15	20	300	200	30	>1,000	4 31 102
401	10	15	10	20	200	300	70	>1,000	28 32 102
404	10	20	15	30	700	200	70	1,000	7 31 101
406	15	10	15	20	500	150	70	>1,000	7 31 101
408	L	10	15	20	500	200	30	150	7 31 101
424	100	20	100	70	1,500	100	>200	200	4 31 101
427	30	50	20	20	300	500	200	200	3 31 101
522	L	15	10	15	300	300	50	>1,000	27 32 102
563	L	10	15	20	300	100	30	1,000	27 32 102
565	15	20	20	50	500	200	100	1,000	28 33 102
570	10	20	20	30	500	300	70	1,000	9 32 102

2/ Contains 30 ppm Sn.

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