STUDIES RELATED TO WILDERNESS

PRIMITIVE AREAS

AN AREA NEAR POPO AGIE, WYOMING

GEOLOGICAL SURVEY BULLETIN 1391-A

Mineral Resources of an Area Near the Popo Agie Primitive Area, Fremont County, Wyoming

By ROBERT C. PEARSON, U.S. GEOLOGICAL SURVEY,
LOWELL L. PATTEN, U.S. BUREAU OF MINES, *and*
DAVID L. GASKILL, U.S. GEOLOGICAL SURVEY

STUDIES RELATED TO WILDERNESS — PRIMITIVE AREAS

GEOLOGICAL SURVEY BULLETIN 1391-A

An evaluation of the mineral potential of the area

UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON : 1973

UNITED STATES DEPARTMENT OF THE INTERIOR

ROGERS C. B. MORTON, *Secretary*

GEOLOGICAL SURVEY

V. E. McKelvey, *Director*

Library of Congress catalog-card No. 73-600208

For sale by the Superintendent of Documents, U.S. Government Printing Office
Washington, D.C. 20402 — Price $1.30 (paper cover)
Stock Number 2401-02403

STUDIES RELATED TO WILDERNESS

PRIMITIVE AREAS

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

CONTENTS

ILLUSTRATIONS

TABLES

MINERAL RESOURCES OF AN AREA NEAR THE POPO AGIE PRIMITIVE AREA, FREMONT COUNTY, WYOMING

By ROBERT C. PEARSON, U.S. Geological Survey, LOWELL L. PATTEN, U.S. Bureau of Mines, and DAVID L. GASKILL, U.S. Geological Survey

SUMMARY

A mineral survey was made, in September and October 1972, of a part of Shoshone National Forest in Fremont County, Wyo., that lies east and south of the Popo Agie Primitive Area. The Area studied, here called the Popo Agie Addition, is about 80 square miles. A similar survey of the primitive area and some adjacent land was made previously and reported in U.S. Geological Survey Bulletin 1353–B. The area of both studies, totaling about 240 square miles, may be discussed when the Popo Agie Primitive Area is considered for inclusion in the National Wilderness Preservation System.

The Popo Agie Addition, except for a small part that contains Paleozoic sedimentary rocks, is geologically similar to the Popo Agie Primitive Area. The rocks are Precambrian igneous rocks, dominantly quartz diorite to quartz monozite — several facies of a large composite batholith that forms much of the southern end of the Wind River Range. Dikes of diabase cut the batholithic rocks. The sedimentary formations, which range from the Cambrian Flathead Sandstone to the Mississippian Madison Limestone, dip 10°–15° NE. off the crystalline core of the range.

Neither geologic mapping and geochemical exploration of the area nor examination of mining claims and prospects has revealed significant accumulations of valuable minerals. Virtually absent are veins, hydrothermally altered rocks, and other evidence of mineralizing processes. Analyses of 145 samples did not produce values sufficiently high to suggest the presence of mineralized rock except for traces at a prospect on Rennecker Peak.

Several groups of mining claims, mostly placer claims, have been staked in the area in the last 75 years. No evidence of prospecting or of potential placer ground was found on any of the placer claims. Of the lode claims, only those on Rennecker Peak show evidence of prospecting. There, a shallow shaft and several small prospect pits contain sparse copper minerals and small amounts of gold and silver but no significant quantity of mineralized rock.

Perhaps 100 tons of granite was quarried before 1945 from along the Middle Popo Agie River less than a mile east of the Popo Agie Addition, and similar granite is abundant nearby. The Paleozoic sedimentary formations contain sandstone, dolomite, and possibly cement rock; however, these rock products are at least equally abundant in places elsewhere in the area, or in the State of Wyoming, where they are more accessible and are closer to markets. Present geologic data indicate that the area has no potential for mineral fuels or geothermal energy.

INTRODUCTION

In 1969 the U.S. Geological Survey and U.S. Bureau of Mines made a mineral survey (Pearson and others, 1971) of the Popo Agie Primitive Area and some adjacent National Forest lands in accordance with provisions of the Wilderness Act and accompanying Conference Report. In 1972 it became evident that other National Forest land east and south of the area already studied would be considered for possible inclusion in the National Wilderness Preservation System. So that all lands being considered for wilderness would have a mineral survey, Geological Survey and Bureau of Mines personnel revisited the area for 8 days in September and October 1972. The geology and mineral resources of an area of about 80 square miles were studied, and the results of this study are reported herein.

This additional land, referred to in this report as the Popo Agie Addition (fig.1), is a narrow strip about 1–5 miles wide and 27 miles long that lies east and south of the Popo Agie Primitive Area. It extends from the Wind River Indian Reservation south across the canyons of the North and Middle Popo Agie Rivers, across Little Popo Agie Basin, and into the headwater area of numerous streams tributary to Sweetwater River.

The Popo Agie Addition lies in the foothills near the southeast end of the Wind River Range. Elevations range from about 7,200 feet in the major canyons to 11,078 feet on Mount Arter in the northern part of the area. More than half the area is tree covered, but much bare rock is exposed along the canyon walls and above timberline on Mount Arter and on the range crest near Christina Lake. Access is good along numerous constructed roads, four-wheel-drive trails, and foot trails.

The only previous geologic studies that bear directly on the Precambrian rocks in the Popo Agie Addition are those by Bayley (1965) and by Pearson, Kiilsgaard, and Patten (1971). Bayley (1965) mapped the Louis Lake 7½-minute quadrangle, and part of that mapping is shown on plate 1 modified only slightly. The sedimentary rocks that crop out along the northeast edge of the Popo Agie Addition have been investigated by several people working in nearby areas. Data on these rocks were summarized by Keefer and Van Lieu (1966), and thicknesses of the several formations have been taken from that source.

Patten and Richard A. Beach examined the U.S. Bureau of Land Management records in Cheyenne, Wyo., and the Fremont County courthouse records in Lander, Wyo., for mining claims in and near the area. They also examined many of these claims on the ground, took samples of mineralized rock, and panned stream gravels. At the same time, geologic mapping and geochemical sampling were done by Pearson and Gaskill. Foot traverses were made along major streams, many ridges, and most trails and roads.

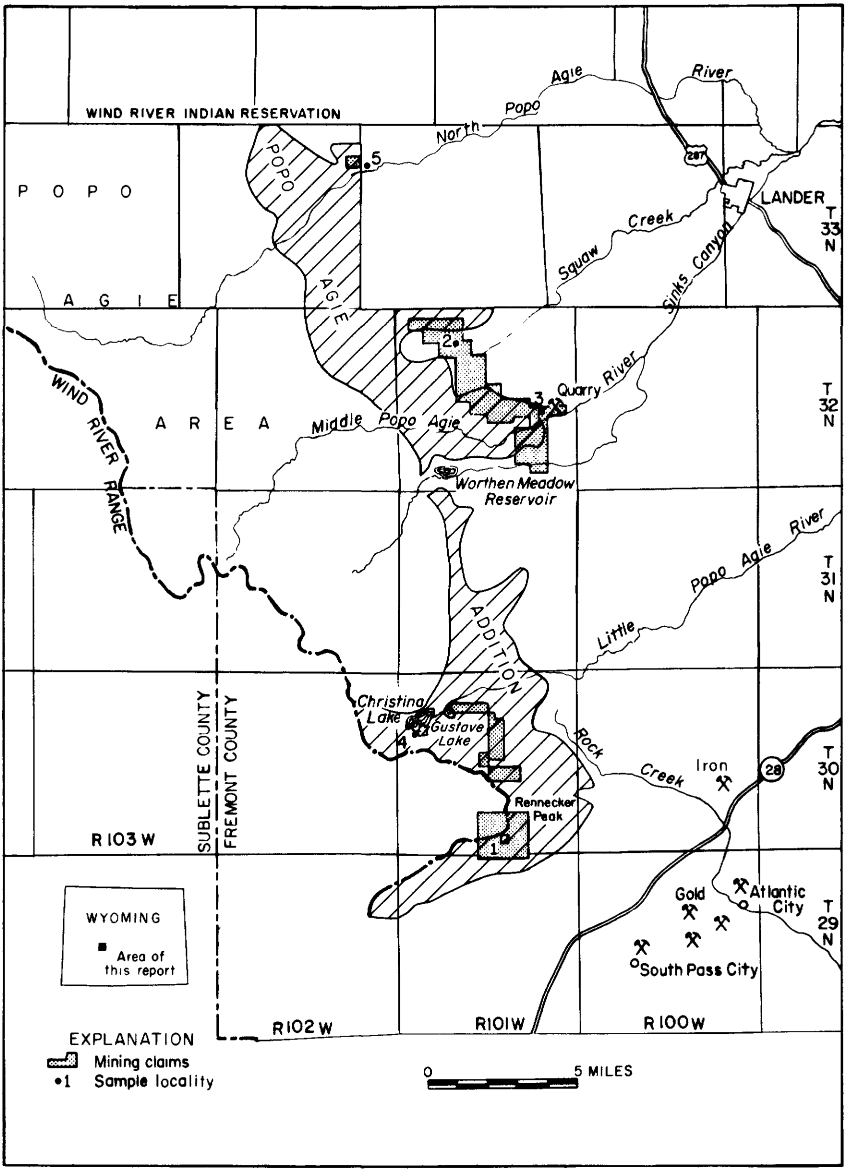

FIGURE 1. — Index map of the southern Wind River Range, showing the Popo Agie Addition and mining claims. Sample localities 1–5 correspond to samples 201–205 in table 4 and on plate 1.

Although numerous claims have been staked in the area and a few prospect pits were found, no mineral production is known, and no evidence of mineral deposits of possible commercial value was found.

GEOLOGY

The Popo Agie Addition lies along the southeast flank of the Wind River Range, largely in Precambrian crystalline rocks that make up the bulk of the range and partly in the Paleozoic sedimentary rocks that lie unconformably on the Precambrian rocks and dip 10°–15° NE. toward the Wind River Basin. Glacial moraines deposited by valley glaciers that came down valleys from the west cover bedrock in many square miles of the area.

PRECAMBRIAN ROCKS

The Precambrian rocks in the Popo Agie Addition are entirely igneous, mostly plutonic, and the rock units that were mapped (pl. 1) are virtually the same as those described by Pearson, Kiilsgaard, and Patten (1971) in the contiguous Popo Agie area to the west. Quartz diorite of the Louis Lake batholith (Bayley, 1965) is the most widespread. Porphyritic quartz monzonite and biotite quartz monzonite, which are tentatively considered to be parts of the Louis Lake batholith, are younger than the quartz diorite. All these plutonic rocks are cut by diabase dikes.

QUARTZ DIORITE OF THE LOUIS LAKE BATHOLITH

Quartz diorite of the Louis Lake batholith crops out along the full 27-mile length of the area studied. The Louis Lake batholith, as defined by Bayley (1965), is composed mainly of gray even-grained to weakly porphyritic biotite-hornblende quartz diorite and locally of granodiorite. The age of the batholith as determined by rubidium-strontium and uranium-lead techniques is about 2.7 b.y. (billion years) (Naylor and others, 1970).

South and east of Christina Lake, the quartz diorite appears to be uniform and homogeneous, and it contains only sparse dikes and veins of granitic rocks. Mafic clots, called metagabbro by Bayley (1965), are conspicuous though volumetrically insignificant; the clots increase in number toward the margin of the pluton a few miles south and southeast of the Popo Agie Addition (Bayley, 1965) and decrease in number to the north. Bayley (1965) included the mafic clots in the batholith, but he excluded from the batholith a selvage of similar rock that he called metagabbro dikes. From the Christina Lake cirque northward, almost every outcrop of the quartz diorite is cut by dikes and veins of felsic rocks, which also form bodies as large as several square miles. Where large enough or abundant enough, they are mapped and described separately as biotite quartz monzonite.

The contact of the quartz diorite with porphyritic quartz monzonite in the canyon of North Popo Agie River and on Black Mountain is gradational over distances of several hundred feet at least. The gradational zone consists of equigranular to seriate biotite quartz monzonite or granodiorite. The small bodies of felsic rocks abundant in the contact zone to the southwest (Pearson and others, 1971) are not so characteristic of the zone in the Popo Agie Addition.

PORPHYRITIC QUARTZ MONZONITE

The east edge of a large mass of porphyritic biotite quartz monzonite occupies a few square miles in the northern part of the Popo Agie Addition. Also, a small body (or bodies) crosses the crest of the range south of Christina Lake. The northern body crops out in the canyon of North Popo Agie River and on Black Mountain, and from there it extends westward at least 12 miles to the west flank of the range (Pearson and others, 1971). The east contact of porphyritic quartz monzonite with quartz diorite is gradational, as described in the preceding paragraph. The south contact (west of the area of pl. 1) is locally sharp, however, crosscutting the weak foliation in the quartz diorite; this suggested to Naylor, Steiger, and Wasserburg (1970) and to Pearson, Kiilsgaard, and Patten (1971) that the porphyritic quartz monzonite was a separate, younger pluton. Although some gradational contacts were also found to the west, the crosscutting relations prompted the designation "Popo Agie batholith" for the porphyritic quartz monzonite (Pearson and others, 1971, p. 12, 15); Naylor, Steiger, and Wasserburg (1970) called it the "Bears Ears pluton." It seems now that the two rocks perhaps are phases of a composite pluton and are of about the same age. The synchronous or slightly earlier quartz diorite may have been partly solid when the porphyritic quartz monzonite began crystallizing. Further work is needed on this problem, but the Louis Lake batholith has been extended tentatively to include the porphyritic quartz monzonite.

BIOTITE QUARTZ MONZONITE

From Christina Lake about 14 miles northward to Cyclone Pass the quartz diorite is intruded by myriad irregular bodies of leucocratic igneous rocks. These rocks are texturally heterogeneous, ranging from pegmatite to alaskite to fine- and medium-grained biotite quartz monzonite. Most outcrops of this unit show gradation among these various rocks, but between McMahone Park and Popo Agie Falls the rock is fairly homogeneous, pinkish, and medium grained, and it contains a few percent biotite.

This unit contains many of the same types of rock as the unit previously called "biotite quartz monzonite of the Popo Agie batholith" (Pearson and others, 1971, p. 16–17) particularly in that (1) inclusions of quartz diorite are characteristic of the unit as mapped and (2) the quartz diorite tends to weather more readily, leaving misleading outcrops of the quartz monzonite and a paucity of quartz diorite in the colluvium.

These rocks form an anastamosing network of dikes and veins in many places, as on Cony Mountain, and the rock in such places was mapped as quartz diorite if that rock seemed to be dominant. At other places the dikes and veins increase in size and number, and the quartz diorite remains only as inclusions within and between the dikes and veins; there, the rock was mapped as biotite quartz monzonite. As a result, the contacts around biotite quartz monzonite, as shown on plate 1, are very generalized and illustrate little more than areas where these rocks are particularly abundant relative to adjacent areas. All the other granitoid rocks contain at least some bodies of rock belonging to this unit. There is some suggestion in the Popo Agie Addition that these rocks grade into porphyritic quartz monzonite; hence, they are probably a phase of a composite batholith and are about the same age as or slightly younger than the porphyritic quartz monzonite.

Fine-, even-grained uniform biotite quartz monzonite intrudes quartz diorite in the canyon of Middle Popo Agie River. Several dikelike bodies about 100–300 feet thick trend northeastward. Elsewhere, apparently the same rock forms crosscutting bodies a few feet to a few tens of feet across. Their relation to rocks of the biotite quartz monzonite is uncertain, and the two have been lumped as a single unit on plate 1 although previously (Pearson and others, 1971) they were mapped separately.

DIABASE

Several northeast-trending dikes of diabase, the youngest of the Precambrian rocks, cut quartz diorite in the southern part of the area, and one similar dike trends north through porphyritic quartz monzonite at the north end of the area. The dikes are long and continuous — some more than 12 miles long — though they do merge and bifurcate (Bayley, 1965). They average about 100 feet in thickness but rarely are as much as 300 feet thick. They have a conspicuous chilled margin. Spall (1971) suggested that these dikes were intruded at least 1.9 b.y. ago, and similar diabase dikes in the Granite Mountains about 50 miles to the east have been dated by Z. E. Peterman (oral commun., 1973) at about 2.5 b.y. old.

PALEOZOIC ROCKS

Paleozoic sedimentary rocks lie unconformably on the Precambrian crystalline rocks all along the east flank of the Wind River Range, and dip 10°–15° NE. In the Popo Agie Addition, Paleozoic rocks are preserved only along the northeast side — from Frye Lake northwest to the Wind River Indian Reservation. Most of the outcropping Paleozoic rocks are Flathead Sandstone of Cambrian age; the younger formations have been eroded. At two places strata as young as the Mississippian Madison Limestone are preserved: (1) at the northern tip of the area and (2) about 6 miles southeast of there, on a hill between Cole Spring and Porcupine Creeks.

The ages and approximate thicknesses of the formations present are given in table 1.

TABLE 1. — *Paleozoic formations in the Popo Agie Addition*

Age	Formation	Thickness[1] (ft)
Mississippian	Madison Limestone	[2] [3]450
Ordovician	Bighorn Dolomite	175
Cambrian	Gallatin Limestone	325
	Gros Ventre Formation	435
	Flathead Sandstone	250

[1]From Keefer and Van Lieu (1966).
[2]Only part of the formation is present in the area.
[3]Darby Formation of Devonian age may be 25± ft thick in this area (Keefer and Van Lieu, 1966); it was not recognized, however, and if present is mapped with Madison Limestone.

QUATERNARY DEPOSITS

GLACIAL DEPOSITS

Lateral moraines composed mainly of till form intermittent ridges along both sides and about 600–1,200 feet above the valley bottoms of the North Popo Agie and Middle Popo Agie Rivers. Near the east side of the area mapped the altitude of the moraines, where they are present, drops abruptly toward a terminus about 6 miles farther east in the North Popo Agie River valley and about 2 miles farther east in the Middle Popo Agie River valley. These moraines are mostly of young till (Pinedale age) and in most places are the only ones recognized. North of the North Popo Agie River, however, an older moraine, probably of Bull Lake age, lies north of the Pinedale lateral moraine between Beauty Lake and Sand Creek and also along the south side of Dickinson Park between the Pinedale moraine and the alluvium in the park.

The most extensive glacial deposits in the Popo Agie Addition are in Little Popo Agie Basin. The three southernmost glaciers in the Wind River Range came out of Silas Canyon, Atlantic Canyon, and the Christina Lake cirque; they merged in Little Popo Agie Basin and moved to a terminus about 2 miles east of the Popo Agie Addition. On melting, they left a morainal deposit about 2½ miles wide in Little Popo Agie Basin. This moraine is presumably all of Pinedale age.

ALLUVIUM

Alluvium has accumulated in low spots at several places behind moraines. It is composed mainly of arkosic sand derived from grus on the bedrock side and sand and gravel derived in part from the adjacent moraine. In most places the alluvium is covered by dense grassy vegetation and a thick peaty soil. At the east side of the area, a mass of talus is shown on the geologic map (pl. 1) on the south side of Middle Popo Agie River.

STRUCTURE

All Precambrian rocks in the area except the diabase dikes are interpreted as parts of a large composite batholith. Despite their great age, these rocks, which are in the interior of the batholith, do not seem to have been deformed to any great extent except for prominent joints and a few faults that have minor offsets. Faults that cut the Precambrian rocks in the Popo Agie area to the west (Pearson and others, 1971) probably cross the Popo Agie Addition, but their traces are buried by surficial deposits.

The Paleozoic sedimentary rocks dip to the northeast off the Wind River Range, which is essentially anticlinal. The uplift formed in latest Cretaceous and early Tertiary time. A few high-angle faults cut the Paleozoic strata in the vicinity of the Popo Agie Addition, but the only one recognized in this study (pl. 1) drops the base of the Flathead Sandstone about 100 feet on its north side. It crosses the North Popo Agie River and is lost in the Precambrian rocks.

MINERAL RESOURCES

SETTING

Except in the Atlantic City district, mineral deposits in the Precambrian core of the Wind River Range have been economically unimportant. Although minor quantities of gold in the Atlantic City district, uranium near the north end of the range, and molybdenum west of the Popo Agie Primitive Area are known, only the iron deposits near Atlantic City have been anything more than minor producers. Located only about 3 miles southeast of the Popo Agie Addition (fig. 1), the iron deposits are in a sequence of low-rank metamorphic rocks — a geologic terrain that differs greatly from that in the Popo Agie Addition. Generally low-grade gold-bearing quartz veins, also in the Atlantic City district, are in that same geologic terrain. The plutonic igneous rocks, which have intruded the iron- and gold-bearing rocks and which constitute most of the rocks in the Popo Agie Addition, are not known to contain any economically important deposits in the Popo Agie Addition or, for that matter, in the entire Wind River Range. In addition to the fact that they are deep-seated igneous rocks, which are generally barren of mineral deposits, the rocks in the area lack other features regarded as favorable, such as strong fracturing, young igneous rocks, and hydrothermally altered rocks. Thus, on the basis of the local and regional geology, there is little likelihood of finding metallic mineral deposits in the Popo Agie Addition.

The sedimentary strata in the northeastern part of the area contain common-variety materials that under certain circumstances of location and economics might be valuable. Sandstone in the Flathead Sandstone might be usable as building stone. Shaly limestone of the Gallatin Limestone may have a composition adequate for use as cement rock. Dolomite in the Bighorn Dolomite may be useful as flux or in magnesia manufacture. None of these materials, however, is rare or in short supply, and in places such as the Popo Agie Addition, remote from population and industrial centers, it is very doubtful that they have any value now or will have any value in the foreseeable future.

GEOCHEMICAL EXPLORATION

Samples of stream sediment and rock were collected in an effort to find concentrations of elements or valuable minerals, which, by being dispersed widely around a mineral deposit, might lead to the discovery of the deposit, whereas the deposit itself might be obscured or overlooked. Analyses of these samples, of which 108 are stream sediment and 32 are rock, are nearly all of normal background quantities, but a few higher-than-normal values show the presence of trace amounts of valuable elements.

The stream-sediment samples, the finest grained silty alluvium available, were collected from stream channels. The samples were dried and sieved; the −80-mesh fraction was analyzed for 30 elements by semiquantitative spectrographic analysis, for gold by atomic absorption, and for citrate-soluble heavy metals (cxHM). The analyses are listed in table 2. Gold analyses are not listed because no gold was detected at the sensitivity limit of 0.05 ppm (parts per million). The analyses in table 2 indicate no concentrations of elements that seem to point to an occurrence of valuable minerals. None of the spectrographic analyses is unusual in any respect. Citrate-soluble heavy metal tests of three samples yielded 8−13 ppm, or as much as about four times background. Sample 116 undoubtedly reflects a diabase dike nearby and is of no significance. Samples 108 and 109 are from tributaries of Silas Creek that drain the south side of Blue Ridge. Because these two values are not very high, they probably reflect a body of mafic igneous rock similar to the diabase dike near sample 116 rather than mineralization of economic interest. No opportunity was available to investigate or resample the area, and the significance of these slightly high values is unknown.

The rock samples were analyzed for 30 elements by semiquantitative spectrographic analysis and for gold by atomic absorption. The analyses are listed in table 3. Gold analyses are not listed in the table because only two samples, from the Rennecker Peak prospect described below, are at or above the sensitivity limit. Analyses of the other rock samples seem to have a composition normal for each rock type.

MINING CLAIMS AND PROSPECTS

The Popo Agie Addition was prospected at least as early as 1897, the year when the first mining claim was staked in the area. Prospectors surely had been in the country before that, for gold was discovered in the Atlantic City district, just 4 miles from the Popo Agie Addition, 55 years earlier, and gold production began there at least 30 years earlier.

No mineral production is known from the Popo Agie Addition. A few tons of granite were quarried for dimension stone from along Middle Popo Agie River just east of the area.

Fremont County records reveal that numerous mining claims have been located in and near the Popo Agie Addition (fig. 1); none of these has been

TABLE 2. —*Analyses of stream-sediment*

[See pl. 1 for sample localities. ppm, parts per million; N, not detected; L, detected but below lower limit of determination; G, for but not found, except as noted: Ag, As, Au, Bi, Cd, Mo, Nb, Sb, Sn, W, and Zn. Spectrographic analyses by J.A. trographic analyses by techniques described by Grimes and Marranzino (1968)]

	Semiquantitative spectrographic analyses									
	(percent)				(ppm)					
Sample	Fe (.05)	Mg (.02)	Ca (.05)	Ti (.002)	Mn (10)	B (10)	Ba (20)	Be (1)	Co (5)	Cr (10)
1/ 1	7	0.7	2	0.7	1,500	L	300	1.5	15	50
2/ 2	2	.7	2	.7	500	N	300	1.5	5	30
3	3	.7	1.5	.7	700	10	300	1.5	15	30
4	3	.7	1.5	.7	700	N	300	1	15	30
5	3	.7	1.5	.7	300	N	200	1.5	10	30
6	3	.7	1.5	.5	300	N	300	1	15	30
12	3	.7	1.5	.5	300	N	300	1	15	50
13	3	.7	1.5	.7	500	15	200	1.5	15	30
14	3	.7	1	.3	300	15	300	1.5	15	50
15	3	.7	1.5	.5	300	15	200	1.5	15	50
16	5	.7	1.5	.5	700	10	300	1.5	15	30
17	2	.7	1.5	.5	300	N	150	1	7	30
18	3	.7	1.5	.7	500	N	200	1	15	30
19	10	.7	2	.7	700	L	150	1	15	70
20	7	.7	2	.5	500	10	300	1.5	15	70
3/ 21	3	.7	1.5	.5	300	10	300	1.5	10	50
22	3	.5	1	.3	1,000	10	300	3	15	50
24	3	.7	1.5	.5	700	20	300	1.5	15	50
25	3	.7	1.5	.3	500	15	200	1.5	10	70
26	3	.5	.7	.3	500	20	200	1.5	15	50
33A	10	.7	2	1	700	L	200	1.5	15	70
34	3	1.5	5	.7	700	10	300	2	15	50
35	10	1.5	7	1	1,500	L	500	1	15	70
38	5	1.5	5	1	1,500	10	300	1.5	15	70
39	10	1.5	5	1	1,500	L	300	1	15	100
40	15	1.5	7	.7	1,500	L	500	1.5	15	100
41	20	1.5	7	1	1,500	L	300	1	20	150
42	10	1.5	7	1	1,500	L	500	1	15	100
43	7	1.5	7	.7	1,500	N	500	1.5	15	70
44	1.0	1.5	5	1	1,500	L	300	1	15	150
45	7	1.5	5	.7	1,500	10	300	1.5	20	100
46	15	1.5	2	.7	1,500	15	300	1.5	15	100
47	10	2	5	1	1,500	L	300	1	15	100
48	15	2	7	1	1,000	10	300	1.5	15	100
49	7	1.5	5	.7	1,500	L	300	1.5	15	100
50	15	1.5	5	.5	700	10	300	1.5	15	100
51	10	2	7	1	1,500	10	300	1.5	20	100
59	7	1	3	.5	200	10	500	1.5	15	70
60	15	2	7	1	1,000	10	300	1.5	15	100
62	7	1.5	5	.5	1,000	15	500	1.5	15	70
63	10	3	7	1	1,500	10	500	1.5	20	100
64	7	1	1.5	.5	700	20	300	2	10	70
65	5	1.5	3	.7	1,000	10	300	1.5	15	50
66	5	1	3	.7	1,500	20	300	1.5	15	70
67	5	.7	3	.7	700	L	300	1.5	15	50
68	3	.7	1.5	.2	700	N	300	2	10	30
70	5	.7	3	.5	1,000	10	300	2	15	50
71	3	.7	2	.5	700	20	300	2	10	50
72	2	.7	1.5	.3	500	10	300	2	10	50
73	2	.5	2	.5	300	N	500	1	10	30

1/ Contains 10 ppm Sn.

2/ Contains 10 ppm Sn.

samples from the Popo Agie Addition

greater than amount shown. Number in parentheses below element symbol is usual lower limit of determination. Also looked
Domenico and R. T. Hopkins; cxHM tests by J. G. Frisken; gold analyses (not shown, see text) by R. B. Carten. Spec-

	Semiquantitative spectrographic analyses--Continued (ppm)								Chemical analyses (ppm)
Sample	Cu (5)	La (20)	Ni (5)	Pb (10)	Sc (5)	Sr (100)	V (10)	Y (10)	Zr (10)	CxHM (1)
1	15	100	20	20	20	300	100	50	500	3
2	15	50	10	30	15	500	70	30	500	2
3	15	70	20	30	15	300	100	30	300	2
4	15	50	20	20	15	300	100	30	500	2
5	15	70	20	30	15	300	100	30	500	2
6	15	70	30	30	15	300	70	30	300	2
12	5	30	20	20	15	300	70	30	200	1
13	10	50	20	30	15	300	100	30	300	1
14	20	70	30	30	15	300	100	30	200	2
15	15	70	30	30	15	300	100	30	500	2
16	15	50	30	30	15	300	100	20	200	1
17	10	30	20	30	15	300	70	30	200	2
18	10	30	20	30	15	300	150	30	300	1
19	7	50	20	20	20	300	200	30	1,000	2
20	15	70	15	30	15	300	100	30	300	1
21	20	30	20	30	15	300	150	30	200	1
22	15	30	20	70	7	300	70	30	300	3
24	20	30	10	30	15	300	100	30	300	1
25	10	70	30	30	15	300	100	30	300	2
26	10	30	20	30	10	300	70	30	300	3
33A	7	30	30	20	20	500	200	30	300	1
34	20	70	20	50	15	500	150	30	300	1
35	20	50	30	50	15	1,000	200	30	300	2
38	20	50	20	30	15	500	150	30	500	4/ 3
39	15	70	30	30	20	500	200	30	300	4/ 5
40	15	50	30	50	20	700	300	30	500	2
41	5	70	30	30	30	700	700	30	700	2
42	7	70	30	30	20	700	300	30	500	2
43	7	50	30	30	20	1,000	300	30	300	2
44	15	70	30	50	20	700	300	30	1,000	2
45	20	30	30	50	20	700	200	30	700	2
46	20	100	30	30	15	500	200	30	500	2
47	15	70	30	30	20	1,000	300	30	700	2
48	7	70	20	30	30	700	300	30	300	2
49	10	70	30	50	30	1,000	300	30	300	2
50	20	50	20	70	20	700	200	30	200	3
51	10	70	20	50	20	700	300	30	300	2
59	15	70	30	50	15	700	150	30	200	4
60	20	70	20	50	20	1,000	200	30	500	4/ 3
62	20	70	30	70	15	700	150	30	200	2
63	50	70	30	70	20	700	200	30	300	2
64	30	30	15	70	10	300	150	30	300	2
65	20	50	30	70	15	500	150	50	300	2
66	10	70	30	50	15	500	150	30	300	2
67	10	30	20	70	15	500	150	30	300	2
68	15	30	15	70	10	300	70	15	100	2
70	15	50	20	100	15	500	150	30	300	4
71	20	100	20	100	15	300	100	30	300	3
72	20	30	20	100	15	300	100	30	300	2
73	20	30	10	100	15	500	100	15	200	2

3/ Contains 15 ppm Sn.

4/ Average of 2 determinations.

TABLE 2.—*Analyses of stream-sediment samples*

Semiquantitative spectrographic analyses

	(percent)				(ppm)					
Sample	Fe (.05)	Mg (.02)	Ca (.05)	Ti (.002)	Mn (10	B (10)	Ba (20)	Be (1)	Co (5)	Cr (10)
74	3	0.5	2	0.5	300	N	300	1	10	30
75	5	.7	2	.5	700	N	300	1.5	15	30
76	3	.5	1.5	.3	300	N	300	1.5	10	50
77	2	.5	1.5	.3	300	N	300	1.5	7	30
78	3	.7	3	.7	700	N	500	1	10	30
80	3	.5	1.5	.3	500	N	300	1	10	30
81	5	.7	2	1	1,000	N	300	1	15	100
82	5	.7	2	.7	1,000	N	300	1	15	70
83	3	.5	2	.7	700	N	500	1	10	20
84	5	.7	3	.7	1,000	N	500	1	10	30
85	5	.5	1.5	.2	500	N	700	1	10	30
86	3	.7	3	.3	700	N	500	1	10	20
87	7	1	5	1	1,000	L	300	1	15	70
89	7	.7	2	1	700	N	700	1.5	15	30
90	5	1	1.5	.5	2,000	50	700	1.5	15	150
91	3	.7	.5	.7	2,000	30	700	1.5	15	100
92	3	.5	1	.3	500	50	300	2	15	30
93	3	1	1.5	.5	500	30	700	1.5	15	70
94	3	.7	7	.3	500	20	500	2	15	50
95	7	1.5	5	1	700	15	700	1	20	70
96	7	1.5	1.5	.7	700	N	300	1	15	30
97	2	.5	1.5	.3	700	N	300	1.5	5	20
98	1.5	.5	1.5	.2	150	N	300	1.5	5	20
99	1	.2	2	.15	150	N	500	1.5	N	N
5/ 100	5	.7	2	1	700	L	300	1.5	15	50
101	5	1	1.5	.7	200	10	300	1.5	15	30
102	2	.5	2	.3	500	N	200	1.5	N	10
103	7	1	1.5	.5	500	L	300	1	15	30
104	5	.7	2	.3	700	L	300	1	L	30
105	1	1	2	.3	1,000	L	200	1	15	30
106	7	.7	3	.7	700	10	200	1.5	15	30
107	7	1	3	.7	700	15	300	1.5	15	30
108	5	1	1.5	.7	300	20	300	1.5	15	70
109	3	.7	1.5	.5	700	N	150	1	15	30
110	3	.7	1.5	.3	500	N	700	1.5	15	20
111	3	1	1.5	.7	500	10	300	1	15	50
112	3	.7	2	.7	500	15	300	1.5	10	30
113	3	.7	1.5	.5	500	N	300	1	10	30
114	3	.7	2	1	700	10	300	1.5	15	30
115	3	.7	2	.5	1,000	10	300	1.5	15	30
116	5	1	1.5	.5	1,000	20	200	1.5	15	100
121	5	.7	1.5	.5	500	20	300	1.5	15	100
122	7	1.5	1.5	.5	700	30	200	1	15	70
124	7	2	5	1	1,000	30	300	1.5	15	150
125	5	2	5	.7	700	15	300	1.5	15	100
126	5	2	1	.1	700	N	150	1	5	10
127	15	2	3	.7	1,000	10	200	1	15	100
128	10	1.5	5	.7	1,000	10	200	1.5	15	100
130	7	1.5	2	.7	500	50	300	1.5	15	100
131	7	1	2	.5	700	30	300	1.5	15	100
132	7	1.5	2	.5	700	20	200	1.5	15	100
133	5	1	1.5	.5	700	20	300	1.5	15	100
134	5	.7	1.5	.7	700	15	300	1.5	15	70
135	7	1.5	1.5	.7	1,000	10	300	1.5	15	70
136	3	.7	2	.3	1,000	N	300	1.5	10	20
137	2	.5	2	.3	500	N	300	1.5	L	20
138	2	.7	1.5	.3	300	N	200	1	10	30
139	7	1	5	.7	1,500	10	300	1	15	70

5/ Contains 10 ppm Sn.

from the Popo Agie Addition — Continued

	Semiquantitative spectrographic analyses--Continued (ppm)									Chemical analyses (ppm)
Sample	Cu (5)	La (20)	Ni (5)	Pb (10)	Sc (5)	Sr (100)	V (10)	Y (10)	Zr (10)	CxHM (1)
74	30	70	10	30	15	500	100	30	300	2
75	50	70	20	100	15	300	150	30	300	3
76	50	100	20	70	15	300	150	30	300	3
77	20	50	15	50	7	300	70	20	300	2
78	30	70	15	70	15	500	150	30	1,000	2
80	30	70	15	50	15	300	100	30	300	2
81	50	70	20	70	15	300	150	50	G1,000	2
82	50	70	15	70	15	300	150	30	500	2
83	50	30	10	50	15	300	70	30	500	2
84	50	70	10	70	15	500	150	50	700	2
85	10	50	10	30	5	500	150	15	300	2
86	10	30	10	30	15	500	100	20	300	2
87	30	100	30	70	20	500	150	70	G1,000	2
89	15	70	10	30	20	700	150	30	1,000	2
90	20	70	30	100	15	300	150	30	500	2
91	50	50	30	100	15	300	150	20	300	2
92	20	30	20	50	7	150	70	30	300	1
93	20	70	30	100	10	300	100	30	500	1
94	10	50	15	100	10	300	100	20	500	2
95	20	70	30	70	30	1,000	150	50	200	2
96	L	30	10	30	15	700	150	30	150	3
97	15	30	7	30	7	500	70	10	70	4
98	15	30	5	30	7	300	70	15	100	2
99	L	20	5	20	5	500	30	N	50	2
100	5	70	15	30	20	500	150	30	200	4/ 4
101	30	70	15	50	15	500	150	30	200	4/ 3
102	10	30	5	30	10	300	70	15	100	4/ 3
103	15	70	10	30	15	500	150	20	150	3
104	7	30	10	50	10	500	70	10	70	2
105	30	30	10	30	15	300	100	20	100	3
106	7	50	10	30	20	300	150	30	200	3
107	15	70	10	50	20	700	150	30	150	5
108	15	70	30	30	15	300	150	30	300	4/ 10
109	20	30	15	20	15	300	100	30	300	4/ 8
110	10	30	10	30	10	700	70	15	100	7
111	7	70	10	30	15	500	100	50	200	4/ 6
112	10	50	7	50	15	500	100	30	300	3
113	20	30	5	30	15	500	100	30	200	4/ 5
114	10	30	5	30	20	700	150	30	500	2
115	15	30	7	50	15	700	100	20	100	4
116	15	70	15	70	15	300	100	20	150	4/ 13
121	20	70	15	50	15	300	100	30	200	5
122	15	70	15	50	15	300	150	30	300	3
124	15	70	30	30	30	700	200	50	300	4/ 3
125	5	70	20	30	15	700	150	30	300	4/ 5
126	L	20	L	20	5	200	70	30	50	4/ 6
127	10	30	30	30	20	700	500	30	500	3
128	10	70	15	30	20	700	200	30	500	4/ 3
130	20	70	30	50	15	500	150	50	500	2
131	10	70	30	30	15	500	150	30	300	5
132	15	70	20	30	15	500	150	30	500	2
133	10	50	20	50	15	300	150	30	300	3
134	10	50	20	30	15	300	150	30	500	4
135	7	50	20	30	15	300	150	30	200	3
136	10	30	5	30	10	500	70	20	200	2
137	5	20	7	30	10	700	70	15	200	2
138	10	30	7	50	10	300	70	20	300	1
139	7	70	30	30	20	700	150	30	300	4

TABLE 3. — *Semiquantitative spectrographic analyses of*

[See pl. 1 for sample localities. ppm, parts per million; N, not detected: L, detected but below lower limit of determination; G, for but not found, except as noted: Ag, As, Au, Bi, Cd, Mo, Nb, Sb, Sn, W, and Zn. Spectrographic analyses by J. A. described by Grimes and Marranzino (1968)]

	Semiquantitative spectrographic analyses									
	(percent)				(ppm)					
Sample	Fe (.05)	Mg (.02)	Ca (.05)	Ti (.002)	Mn (10)	B (10)	Ba (20)	Be (1)	Co (5)	Cr (10)
7	7	1.5	5	0.5	700	L	300	1	15	30
8	3	.5	1	.2	300	N	300	1	N	15
9	7	1	2	.3	500	N	500	1	15	30
10	1.5	.1	.2	.1	150	N	300	L	N	N
11	7	1.5	2	.5	500	L	500	1	15	50
23	.7	.07	.3	.07	100	N	150	1	N	N
27	1	.1	.5	.05	150	N	100	2	N	L
28	5	3	1.5	.7	500	L	L	L	15	50
29	10	7	5	.7	2,000	L	150	2	30	500
30	10	7	7	1	2,000	L	300	1.5	70	700
31	5	.2	.1	.05	100	L	L	L	N	10
32	7	.3	10	.5	700	L	150	1	N	20
33	1.5	.3	1	.15	200	N	500	L	N	L
1/ 36	.7	.07	.5	.05	100	N	L	3	N	N
37	5	.7	2	.5	500	N	500	1	15	15
52	10	2	5	1	1,000	L	100	1	50	200
53	10	50	7	.7	1,500	10	150	N	50	200
54	5	.7	7	.3	500	N	150	1	5	70
55	10	2	3	G1	1,500	10	100	N	70	50
2/ 56	15	3	5	.7	1,500	L	150	N	50	700
3/ 57	10	2	3	.7	1,000	10	1,500	N	50	700
58	7	2	2	.3	700	10	200	1	15	50
61	1	.2	1	.1	150	N	500	1	5	L
69	1.5	.5	.5	.2	200	N	700	1.5	5	10
79	2	.5	1.5	.2	200	N	500	2	5	L
88	5	.7	1.5	.3	300	N	500	1	10	15
117	5	1	2	.3	500	N	500	1.5	15	30
118	5	.7	1.5	.2	500	N	300	1	10	15
119	.3	.07	.2	.03	150	N	150	1.5	N	20
120	10	3	7	1	1,000	10	200	1	20	100
123	5	.7	2	.3	300	N	500	1	15	15
129	10	.3	5	1	1,500	L	100	N	70	200

1/ Contains 20 ppm Nb. 2/ Contains 5 ppm Ag. 3/ Contains 5 ppm Ag.

patented. Most of the claims are placer claims whose boundaries are described in terms of land lines. Some of the claims are lode claims whose descriptions are so vague that their outlines in figure 1 are only generalized.

NORTH POPO AGIE RIVER

A placer claim dated 1897 covers 160 acres mostly in the canyon of the North Popo Agie River near the mouth of Sand Creek. It occupies the NE¼ sec. 12, T. 33 N., R. 102 W. Neither the bottom nor the steep walls of the canyon contain much prospective placer ground. Loose slabs of quartzite and glacier boulders, mostly granitic rocks, are scattered over the slopes, and a small amount of sand has been deposited between boulders in the riverbed. The bedrock in the canyon is largely quartz diorite, which occupies most of this claim; the quartz diorite is capped by Flathead Sandstone along the north edge of the claim; and in that same area part of a glacial moraine covers about 40 acres of the quartz diorite and sandstone. No workings were found.

rock samples from the Popo Agie Addition

greater than amount shown. Number in parentheses below element symbol is usual lower limit of determination. Also looked
Domenico and R. T. Hopkins; gold analyses (not shown, see text) by R. B. Carten. Spectrographic analyses by techniques

Semiquantitative spectrographic analyses--Continued

Sample	Cu (5)	La (20)	Ni (5)	Pb (10)	Sc (5)	Sr (100)	V (10)	Y (10)	Zr (10)	Rock type
	(ppm)									
7	50	100	10	30	10	700	150	15	200	Granodiorite.
8	70	100	L	50	5	200	50	15	200	Quartz monzonite.
9	50	70	10	30	15	500	150	30	200	Quartz diorite.
10	20	10	L	30	L	300	10	L	200	Quartz monzonite.
11	10	70	15	10	10	700	150	20	300	Quartz diorite.
23	30	10	L	70	L	N	10	10	30	Quartz monzonite.
27	20	30	L	70	L	100	20	10	70	Do.
28	30	50	20	N	15	300	150	30	300	Quartz diorite.
29	15	70	70	20	50	700	300	70	300	Mafic clot.
30	150	70	200	15	30	700	500	50	500	Do.
31	30	20	L	N	L	N	100	N	50	Quartz-hematite vein.
32	30	100	L	50	15	2,000	200	15	200	Quartz-epidote rock.
33	50	70	L	100	5	100	30	10	150	Porphyritic quartz monzonite.
36	30	20	L	150	5	N	10	15	30	Pegmatite.
37	20	30	15	30	5	700	150	10	200	Quartz diorite.
52	50	30	30	10	50	200	1,000	50	200	Diabase.
53	100	20	100	N	50	300	700	30	100	Diorite.
54	20	30	7	30	10	1,500	150	10	100	Epidotized quartz diorite.
55	50	20	30	N	50	200	700	50	150	Diabase.
56	5,000	150	150	20	50	500	500	50	70	Mafic clot.
57	2,000	30	150	100	15	700	700	N	150	Do.
58	150	50	20	20	10	300	150	20	100	Quartz diorite.
61	30	20	L	50	5	500	30	N	70	Quartz monzonite.
69	50	50	L	50	5	300	30	10	70	Do.
79	50	70	L	150	7	300	50	10	100	Porphyritic quartz monzonite.
88	30	100	L	30	5	300	70	10	300	Quartz monzonite.
117	70	70	15	30	10	700	100	20	200	Quartz diorite.
118	50	50	10	30	7	500	70	15	70	Quartz monzonite.
119	15	N	L	150	L	L	L	15	10	Pegmatite.
120	50	100	100	20	20	1,000	300	50	100	Mafic clot.
123	50	30	15	20	15	500	150	15	200	Quartz diorite.
129	150	20	100	N	50	200	700	30	100	Diabase.

A sample of alluvium was collected from the north bank of the river near the east boundary of the claim. The sample was panned, and the concentrate analyzed (table 4, sample 205). No gold was visible in the pan, and no gold or unusual concentration of other elements was disclosed by the analysis. Samples of stream sediment taken from the mouth of Sand Creek and nearby from North Popo Agie River have normal metal content (table 2, samples 82 and 83.)

SQUAW CREEK — MIDDLE POPO AGIE RIVER

A large group of placer claims, recorded in 1897, is adjacent to the east boundary of the area largely in the drainage of Squaw Creek and Middle Popo Agie River (fig. 1). The claimed area lies mostly on the dip slope of the Flathead Sandstone and fragments of shale and limestone from the Gallatin and Gros Ventre Formations.

Two samples of material from the banks of streams were obtained by panning; and the concentrate was analyzed (table 4). Sample 202, mostly

TABLE 4. — *Spectrographic and atomic absorption analyses of samples from the Popo Agie Addition*

[See pl. 1 for sample localities. Analyses by Skyline Labs, Inc., Wheatridge, Colo. <, less than number shown: ---, not analyzed. Fe, Ca, and Mg are in percent; all others in parts per million]

Element	Sample				
	[1]201	[2]202	[2]203	[3]204	[2]205
	Semiquantitative spectrographic analyses				
Fe	7	20	20	15	20
Ca	3	.5	.5	1.5	1
Mg	5	.1	.1	.5	1
Ag	<1	1	<1	<1	<1
As	<500	<500	<500	<500	<500
B	10	100	50	20	50
Ba	1,000	70	50	700	70
Be	<2	<2	<2	<2	<2
Bi	<10	<10	<10	<10	<10
Cd	<50	<50	<50	<50	<50
Co	20	20	30	10	20
Cr	150	200	200	100	300
Cu	200	10	2	5	2
Ga	50	50	100	50	70
Ge	<20	<20	<20	<20	<20
La	100	<20	<20	<20	<20
Mn	1,000	700	700	500	1,000
Mo	<2	10	20	3	15
Nb	<20	20	20	20	20
Ni	50	150	50	10	200
Pb	10	70	<10	10	<10
Sb	<100	<100	<100	<100	<100
Sc	20	20	<10	15	10
Sn	<10	150	10	<10	10
Sr	1,500	50	100	1,000	100
Ti	5,000	2,000	2,000	3,000	2,000
V	300	500	500	300	500
W	<50	<50	<50	<50	<50
Y	30	100	20	30	30
Zn	200	<200	<200	<200	<200
Zr	200	700	500	500	500
	Atomic absorption analyses				
Au	<0.02	<0.10	<0.02	<0.02	<0.02
Ag	<.2	------	------	------	------

[1]Rock.
[2]Panned concentrate.
[3]Sand.

sand, was from the north bank of Squaw Creek in west-central sec. 9, T. 32N., R. 101W. Sample 203, mostly sand, was from the north bank of Middle Popo Agie River in east-central sec. 23, above the upper bridge in Sinks Canyon. No gold was visible in either concentrate, and the analyses indicated nothing of interest.

The reason for location of the claims remains obscure. Perhaps small amounts of gold at the base of the Cambrian formations in the Bighorn Mountains of north-central Wyoming (Darton, 1906) may have influenced this activity. No workings were found in this vicinity except the quarry discussed in the next paragraph.

Several lode mining claims (not shown in fig. 1) have been located along Middle Popo Agie River above Sinks Canyon since 1928. Immediately northwest of the upper bridge, near the site of sample 203, several large boulders of gray granite have been split, apparently by quarrying equipment such as plugs and feathers. Examination of the split boulders indicates that about 100 tons have been removed. Several of the remaining boulders contain iron rings that probably were anchor points for a derrick. This rock, which is a type that is abundant in the general vicinity, was removed before 1945 and used for monuments (Osterwald and others, 1966).

Areas north and south of Worthen Meadow Reservoir contain several mining claims that were investigated previously (Pearson and others, 1971). No recent developments were noted in this area during the present investigation.

LOUIS CREEK

A block of placer mining claims, located in 1916, includes parts of secs. 8, 9, 10, 15, 16, and 22, T. 30 N., R. 101 W. Neither mineral deposits nor workings were found in the area. These claims are arranged in an irregular line that is traversed by a ditch that diverted water from Little Popo Agie River below the outlet of Gustave Lake across the head of Louis Creek to Rock Creek. According to Spencer (1916, p. 44), who quoted Emile Granier, an engineer, the ditch was dug in 1885 to supply water to placer workings farther down Rock Creek and other streams.

RENNECKER PEAK

A group of 84 claims, located in 1968, includes all of sec. 34 and parts of secs. 26, 27, 28, 33, and 35, T. 30 N., R. 101 W. A prospect shaft and a few small prospect pits about 300 feet east of the top of Rennecker Peak explored a small part of the Louis Lake batholith that is characterized by closely spaced clots of mafic rock. The shaft was dug beside a diabase dike a few feet thick; a thicker parallel diabase dike is about 100 feet to the northwest. There is no evidence of faults or veins or of alteration and mineralization in the workings other than some specks of malachite scattered through a few of the mafic clots and a few marble-sized lumps of chalcopyrite found on the dump. The mafic clots range in length from about an inch to about 2 feet, are elliptical in cross section, have long axes about 50 percent longer than short axes, are of several lithologic types differing in mineral composition and grain size, and are separated by a matrix of leucocratic rock. The clots consist of the same minerals that are in the surrounding quartz diorite; but in the clots the mafic minerals are relatively more abundant. Chlorite, sericite, and a zeolite are petrographic evidence of slight alteration. Copper minerals identified petrographically are mainly bornite and chalcopyrite; minor amounts of chalcocite and covellite are probably secondary.

Samples 56 and 57 (table 3) taken from the dump of the prospect shaft evidently are parts of the most mafic of the clots. They contain respectively 0.5 and 0.2 percent copper and 0.05 and 0.10 ppm gold, and each contains 5 ppm silver. These two samples were selected as the highest grade available, and they do not represent any appreciable quantity of rock. A grab sample (table 4, sample 201) of the dump contained 200 ppm copper; it may be representative of the grade of the dump and an additional small tonnage.

About 2,000 feet southwest and 500 feet lower than this shaft, a prospect pit was dug along the edge of the thicker diabase dike that crosses the top of the peak. No evidence of mineralization was found, and a sample of altered quartz diorite (table 3, sample 58) from the dump contained only 150 ppm copper and no other elements in economically interesting quantities. The likelihood of a minable deposit on Rennecker Peak is virtually nil.

CHRISTINA LAKE

On the ridge south of Christina Lake a few small prospect pits were dug on quartz-hematite veins and altered quartz diorite near an altered mafic dike, which has been cut by pegmatite. Samples 31 and 32 from these pits contained no elements in quantities of interest (table 3).

A claim encompassing SE¼SE¼ sec. 7, T. 30 N., R. 101 W., was recorded in 1916. In part it includes a sandy beach on the south shore of Christina Lake. Some of the sand has been concentrated to a heavy fraction by wave action. Sample 204 (table 4) consisted of this "black sand," which upon analysis showed no unusual components.

REFERENCES CITED

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

Darton, N. H., 1906, Mineral resources of the Big Horn Mountain region [Wyoming]: U.S. Geol. Survey Bull. 285–F, p. 303–310.

Grimes, D. J., and Marranzino, A. P., 1968, Direct-current arc and alternating-current spark emission spectrographic field methods for the semiquantitative analysis of geologic materials: U.S. Geol. Survey Circ. 591, 6 p.

Keefer, W. R., and Van Lieu, J. A., 1966, Paleozoic formations in the Wind River basin, Wyoming: U.S. Geol. Survey Prof. Paper 495–B; 60 p.

Naylor, R. S., Steiger, R. H., and Wasserburg, G. J., 1970, U-Th-Pb and Rb-Sr systematics in 2700×10^6 year old plutons: Geochim. et Cosmochim. Acta, v. 34, p. 1133–1159.

Osterwald, F. W., Osterwald, D. B., Long, J. S., Jr., and Wilson, W. H., 1966, Mineral resources of Wyoming: Wyoming Geol. Survey Bull. 50, 287 p.

Pearson, R. C., Kiilsgaard, T. H., and Patten, L. L., 1971, Mineral resources of the Popo Agie Primitive Area, Fremont and Sublette Counties, Wyoming, *with a section on* Interpretation of aeromagnetic data, by R. E. Mattick: U.S. Geol. Survey Bull. 1353–B, 55 p. [1972].

Spall, Henry, 1971, Paleomagnetism and K-Ar age of mafic dikes from the Wind River Range, Wyoming: Geol. Soc. America Bull., v. 82, no. 9, p. 2457–2472.

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.

☆ U.S. GOVERNMENT PRINTING OFFICE: 1973 O—543–576/5