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THE POISON RIDGE VOLCANIC CENTER AND RELATED MINERALIZATION, GRAND AND JACKSON COUNTIES, COLORADO

By DOUGLAS M. KINNEY, GLEN A. IZETT, ROBERT U. KING, and RICHARD B. TAYLOR

Abstract

The Poison Ridge volcanic center, of probable middle Tertiary age, in the Rabbit Ears Range, Grand County, Colo., is surrounded by a zoned halo of intense hydrothermal alteration. An inner alteration zone of intensely fractured rock veined by quartz, hematite, and feldspar is surrounded by a zone characterized by quartz, sericite, and pyrite. Geochemical anomalies in the altered area indicate that the altered rock offers a potential target at depth for exploration for disseminated molybdenum and perhaps copper.

INTRODUCTION

In the course of regional mapping in the Rabbit Ears Range, northwestern Colorado, an extensive area of red-stained pyritic rocks south of Poison Ridge was discovered by D. M. Kinney of the U.S. Geological Survey. Stream-sediment samples taken downstream from the altered area in the summer of 1967 by Kinney and D. L. Wheat were analyzed using semiquantative spectrographic methods and were found to contain anomalous amounts of several metals. Samples of hydrothermally altered rocks taken late in October 1967 by G. A. Izett and R. B. Taylor also had anomalous metal contents, but further work was halted by snow. The area of altered rocks and an area peripheral to it were studied in more detail during July 1968 by Izett, Taylor, and R. U. King. This work showed that the altered and mineralized rocks are closely associated with a volcanic center of probable middle Tertiary age, and the pattern of alteration and distribution of metal concentrations suggests that potential targets for exploration may be present at depth.

This igneous center, here designated the "Poison Ridge volcanic center," is on the south side of the Continental Divide between North Park and Middle Park, about 20 miles north-northeast of Kremmling and 9 miles south-southwest of Rand, Colo. (fig. 1). A quartz latite porphyry stock cutting clastic sedimentary rocks of the Middle Park Formation of Late Cretaceous(?) and Paleocene age (fig. 2) is surrounded by asymmetric zones of contact metamorphism and hydrothermal alteration. The northwestern part of the stock and adjacent wallrocks were closely fractured and veined by quartz, hematite, and feldspar. An alteration halo 1½ miles across characterized by quartz, sericite, and pyrite surrounds this inner zone.

Semiquantitative spectrographic analyses of samples of the hydrothermally altered rocks show that molybdenum content—Mo, 10–150 ppm (parts per million)—is highest in the inner alteration zone and that copper and lead contents—Cu, 15–150 ppm; Pb, 10–300 ppm—are highest in the outer zone. All surface rocks have been leached and the sulfides at least partially oxidized; the analytical results reflect both the hypogene and supergene alteration.

The Poison Ridge center is easily reached from Rand, Colo., by way of a county road along Willow Creek, and thence via Forest Service Road 2042 to the Continental Divide at the east end of Poison Ridge.

GEOLOGIC SETTING

In latest Cretaceous(?) and early Tertiary time, the Poison Ridge area was part of a large sedimentary basin lying between the Front Range to the east and the Park and Gore Ranges to the west. This intermontane basin

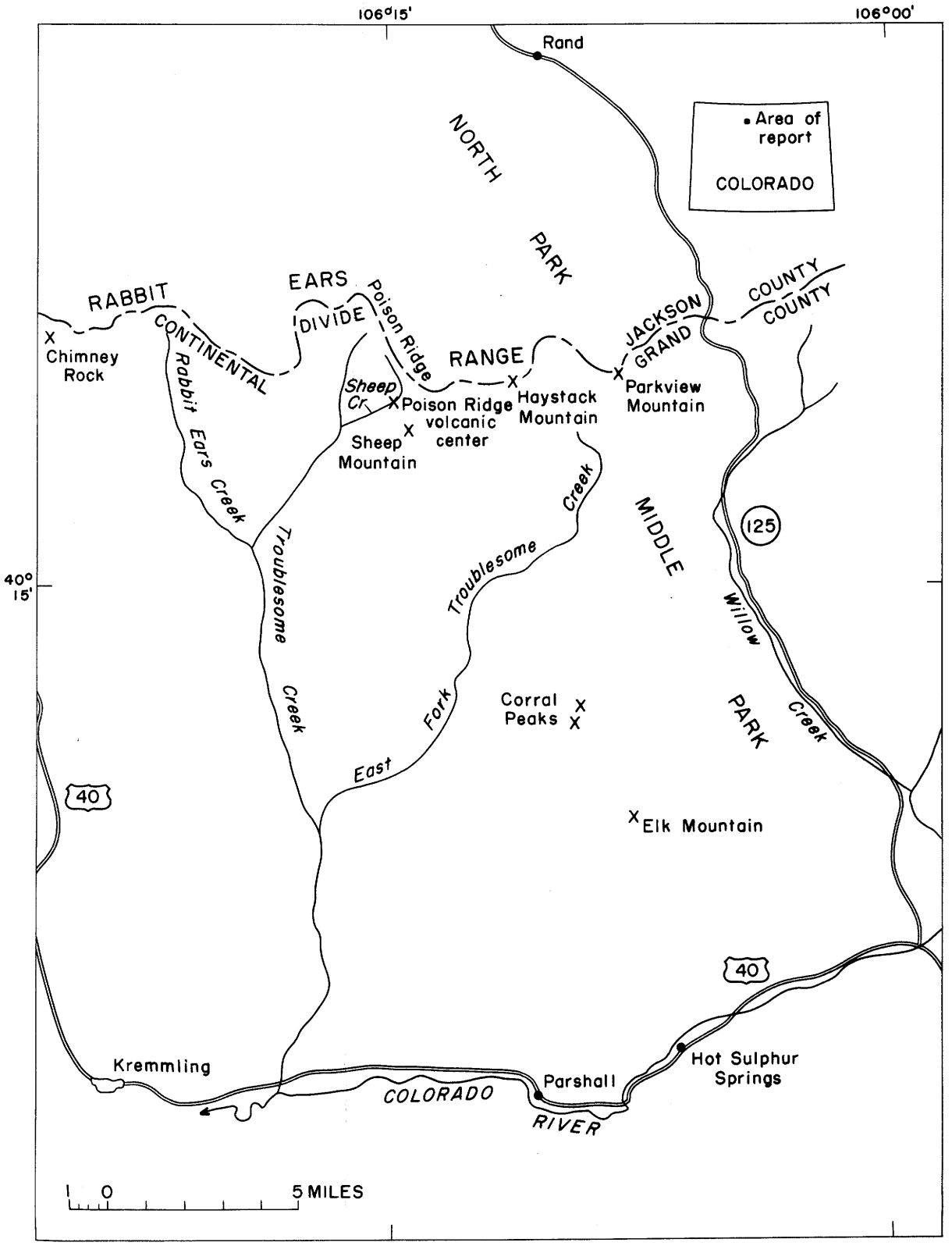

FIGURE 1.—Index map showing location of Poison Ridge volcanic center, Colorado.

was formed early in the Laramide orogeny when tectonic movements outlined some of the main elements of the Southern Rocky Mountains. Debris shed from these early boundary ranges and from andesitic volcanic centers in and along the west side of the Front Range accumulated in the basin to form clastic deposits called the Middle Park Formation. The early upwarps were more closely folded and faulted during later Laramide orogenic episodes, and the Middle Park Formation was extensively deformed. Following the final Laramide tectonic activity in late Eocene time and the accompanying erosion, silicic volcanism began in Oligocene time. One volcanic field, which covered an upland area underlain by the Middle Park Formation, now makes up the Rabbit Ears Range. Quartz latite and latite pyroclastic rocks and flows (Rabbit Ears Volcanics) were extruded from several igneous centers. These centers, including the Poison Ridge center, are marked in the present terrain by sills, dikes, and small stocks cutting the underlying sedimentary rocks. Most of the volcanic activity probably took place in Oligocene time, but volcanism may have continued into Miocene time. Basalt plugs and flows formed after silicic volcanism. These rocks have been assigned tentatively to the Pliocene because some of the flows rest on well-dated Miocene sedimentary rocks northwest of Hot Sulphur Springs.

MIDDLE PARK FORMATION

The Middle Park Formation of Late Cretaceous(?) and early Tertiary age is the only sedimentary unit exposed in the vicinity of the Poison Ridge center. The base of the formation is not exposed near the stock, but about 8 miles southwest, the Middle Park beds rest unconformably on the Pierre Shale of Late Cretaceous age. As described by Tweto (1957), the formation typically is a sequence of interbedded arkosic conglomerate, sandstone, and mudstone at least 6,000 feet thick. Virtually unaltered outcrops of the formation near the Poison Ridge stock occur along north-flowing tributaries of Sheep Creek on the north flank of Sheep Mountain in the NW¼ sec. 16, T. 4 N., R. 79 W. (unsurveyed). The conglomerates and sandstones at this locality are typical of the Middle Park Formation and are easily recognized by the fragments of Precambrian rocks and Laramide porphyries that they contain. Interlayered mudstones contain abundant mica and are dark and massive. The Middle Park Formation is less easily identified around the Poison Ridge stock, where the rocks are baked and hydrothermally altered.

RABBIT EARS VOLCANICS

Extrusive fragmental volcanic rocks and flows of the Rabbit Ears Volcanics of Oligocene and Miocene(?) age (Izett, 1966) overlie the Middle Park Formation. The formation is as much as 1,500 feet thick and crops out in an arcuate pattern on the west side of the Poison Ridge stock (fig. 2). The formation is made up of interbedded tuff, tuff breccia, and volcanic breccia interlayered with a few lava flows. The breccia fragments are composed of several types of porphyritic intermediate volcanic rocks including biotite- and hornblende- and pyroxene-bearing latite, quartz latite, and rhyodacite porphyry. Sparse fragments of rhyolite welded tuff containing quartz phenocrysts also occur in the breccia. The flows are chiefly latite and quartz latite in composition, but trachybasalt flows have been found locally near the base of the formation. Numerous dikes, sills, and larger discordant masses of porphyry cut both the extrusive rocks of the Rabbit Ears Volcanics and the underlying sedimentary rocks and are clearly related to the middle Tertiary period of igneous activity.

POISON RIDGE VOLCANIC CENTER

The Poison Ridge volcanic center is marked by a composite quartz latite porphyry stock that is the focus of a radiating dike swarm and is surrounded by a zone of baked and hydrothermally altered rocks of the Middle Park Formation.

The Poison Ridge stock is rudely ovoid in plan and measures about 2,600 feet along its northwest axis and about 1,500 feet along its northeast axis. It is best exposed in the northwest-facing cliffs along Sheep Creek; in most other places, it is covered by talus and rock slides. Its contacts are generally covered except on the northwest side where relations are partially masked by rock alteration. The contact on this side seems to be steep, perhaps vertical.

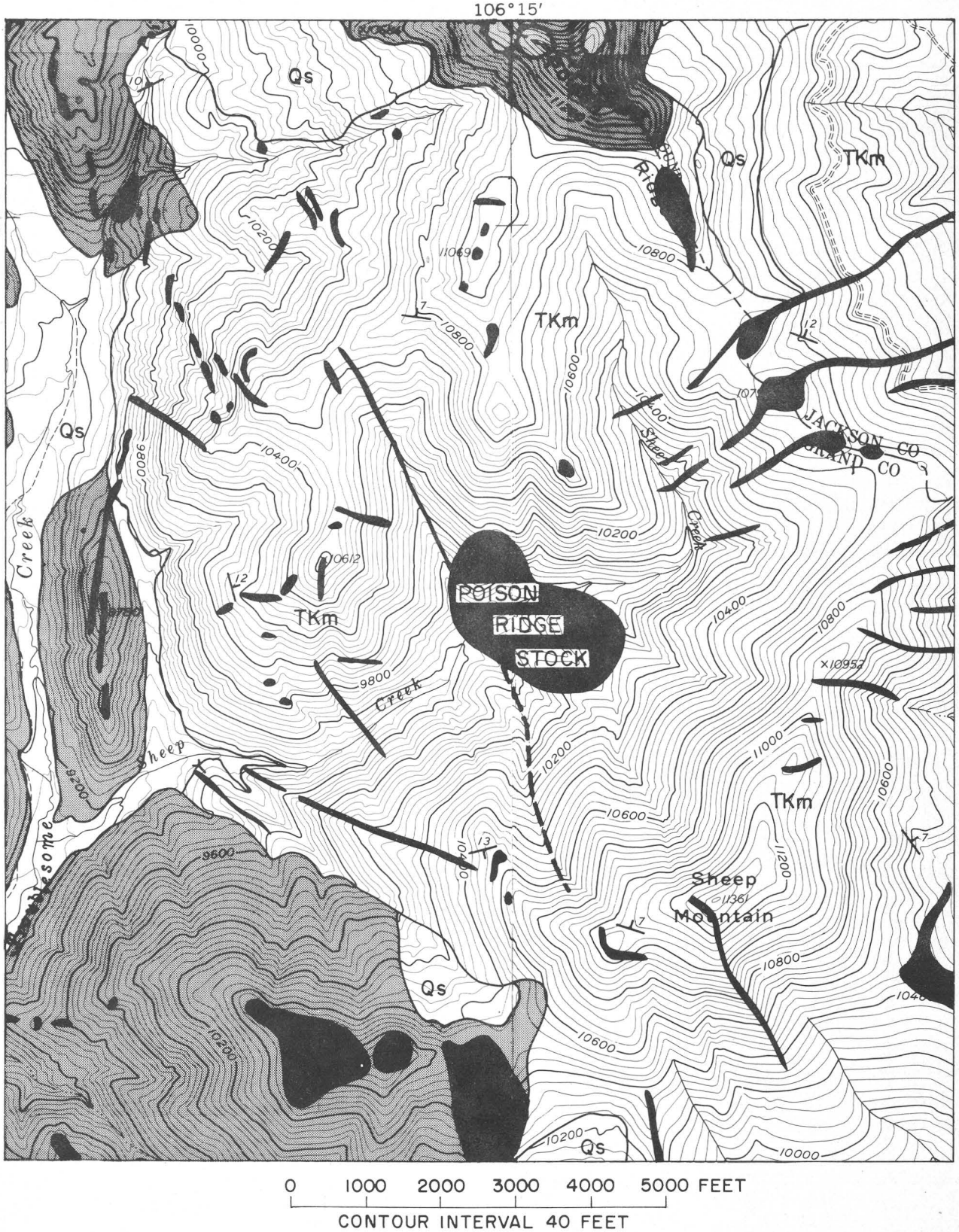

FIGURE 2.—Preliminary geologic map of the Poison Ridge volcanic center, Grand and Jackson Counties, Colo. Base map from U. S. Geological Survey, scale 1 : 24,000—Hyannis Peak and Parkview Mountain, 1956. Geology by D. M. Kinney with additions by G. A. Izett, R. U. King, and R. B. Taylor.

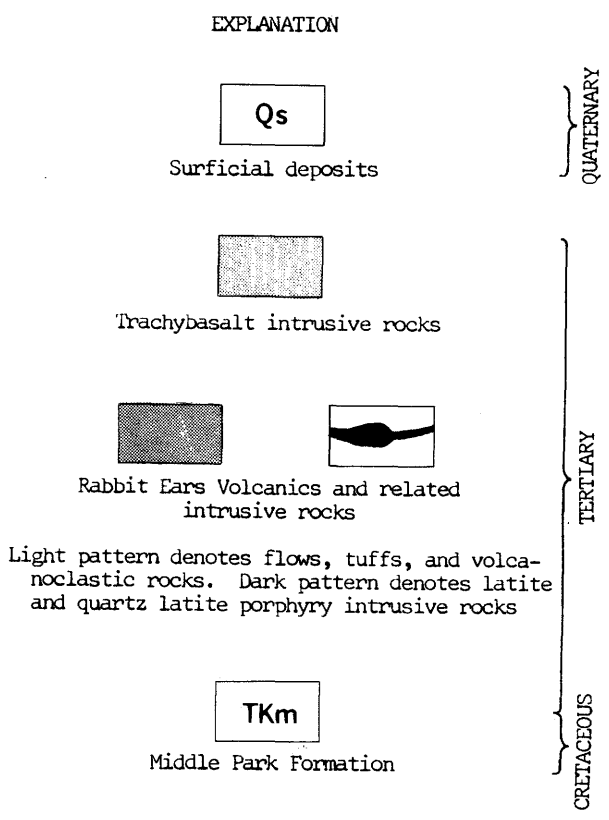

FIGURE 2.—Continued.

The principal rock type of the Poison Ridge stock is a light-gray quartz latite porphry. Gray feldspar phenocrysts from 2 cm (centimeters) to less than 1 mm (millimeter) long and dark-greenish-gray hornblende crystals as much as 5 mm long are set in a gray matrix of quartz and feldspar with lesser quantities of other minerals. Rare phenocrysts of clinopyroxene or bipyramidal quartz were observed in a few specimens. In thin section, the rock is a seriate porphyry. The largest phenocrysts are orthoclase, with complex oscillatory zoning. The plagioclase phenocrysts are oligoclase, also with complex oscillatory zoning and complex twinning. The hornblende phenocrysts are tan to greenish tan in transmitted light, are sieve-like with many inclusions of other minerals, and have irregular outlines. The groundmass is a granular to subgraphic intergrowth of cloudy perthite and quartz. The perthite also thinly mantles both orthoclase and plagioclase phenocrysts. The modal composition of the principal rock type in the stock is quartz latite.

Modal analyses, in volume percent, of rocks from the Poison Ridge stock

[Tr, trace]

	1	2
Phenocrysts:		
Oligoclase	25	28
Orthoclase	9	9
Hornblende	7	5
Clinopyroxene	--	1
Groundmass:		
Perthite	45	40
Quartz	10	14
Biotite	1	1
Magnetite	2	1
Zircon	Tr	Tr
Apatite	Tr	Tr
Sphene	Tr	Tr
Alteration minerals:		
Chlorite	1	Tr
Nontronite	Tr	1
Sericite	Tr	Tr

1. 300 feet from northeastern contact of stock, about 100 feet above Sheep Creek.
2. 200 feet from northeastern contact of stock, about 100 feet above Sheep Creek.

Mineralogic and textural variations in the rocks found in talus covering the stock suggest that several different porphyry types are present. Scattered inclusions of dark hornblende-rich porphyry in the outcrops of lighter colored quartz latite porphyry on Sheep Creek furnish the only clear evidence of relative age. The predominant coarse porphyry of the stock

seems to be the last in an intrusive sequence of generally finer grained quartz latite porphyries.

A similar varied assemblage of porphyries makes up a group of dikes that radiate outward from the Poison Ridge stock (fig. 2). These rocks are principally quartz latite porphyries in which an aphanitic groundmass encloses abundant feldspar and hornblende phenocrysts. Many additional dikes were not mapped because of their small size, or because they are masked by hydrothermal alteration, or because of poor outcrop and talus cover.

The radial dike pattern, the complex central stock, and the similarities of the porphyry types to extrusive rocks in the Rabbit Ears Volcanics suggest that the Poison Ridge stock represents the subvolcanic core of a volcano that supplied pyroclastic rocks and flows to the Rabbit Ears Volcanics.

ROCK ALTERATION AND MINERALIZATION

The Poison Ridge stock is enveloped by metamorphosed and hydrothermally altered rock. The mudstone layers of the Middle Park Formation have been partially recrystallized as far as 2,000 feet from the stock. The mudstone has been baked to a black hard dense hornfels composed of quartz, feldspar, chlorite, and sericite. Interlayered sandy mudstone, sandstone, and conglomerate beds are bleached and have been partially sericitized and locally silicified.

A highly asymmetric hydrothermal alteration pattern has been developed around the stock (fig. 3). Closely spaced and intersecting fractures and intensely altered rock are concentrated within the northwest part of the stock and in the adjacent sedimentary rocks. In this inner zone, the host rocks are altered to quartz and feldspar and contain variable amounts of pyrite, muscovite, and biotite (fig. 4); the innumerable minor fractures are filled by narrow quartz-hematite-feldspar veinlets. This inner alteration zone grades outward into a peripheral zone of altered rock characterized by quartz, sericite, and pyrite.

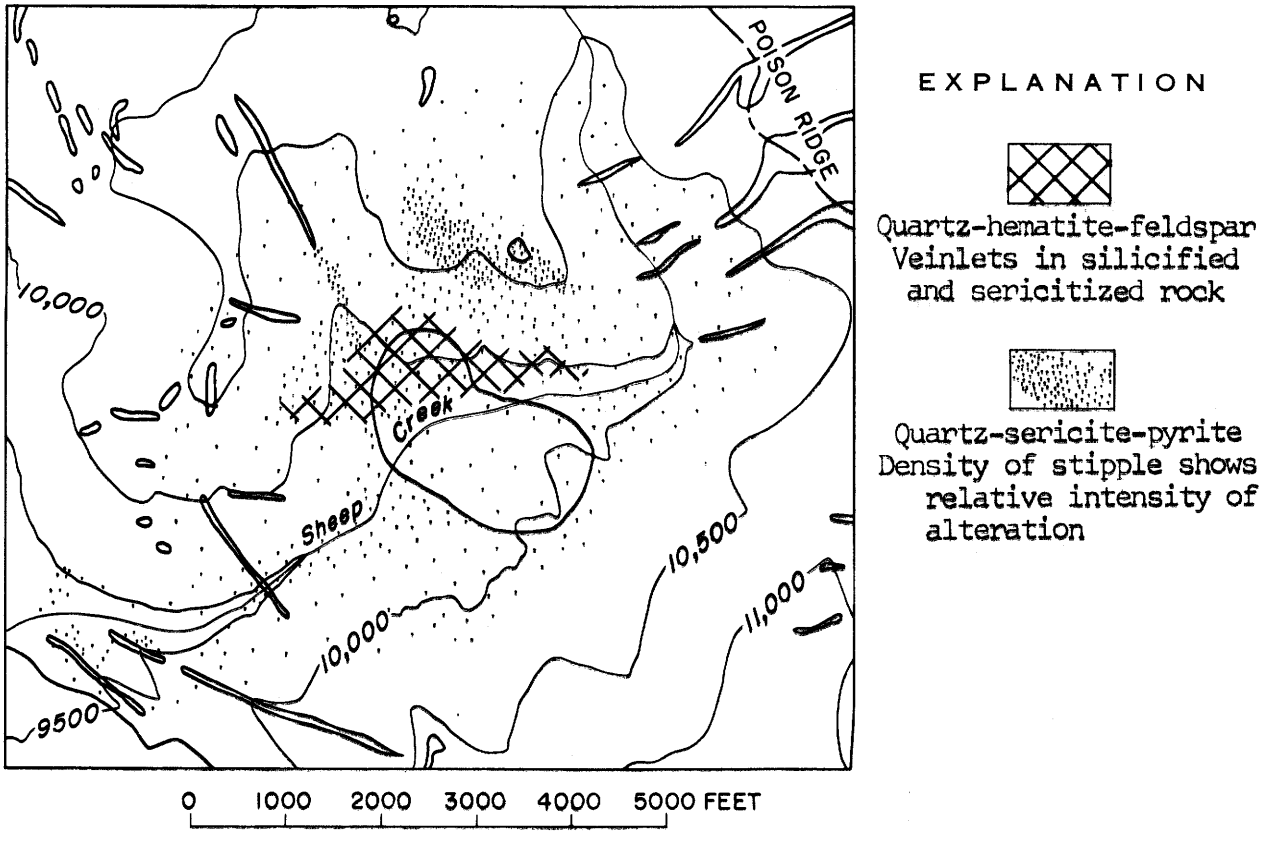

FIGURE 3.—Distribution of rock alteration around the Poison Ridge volcanic center (compare with fig. 2). Bedrock units are shown in figure 2.

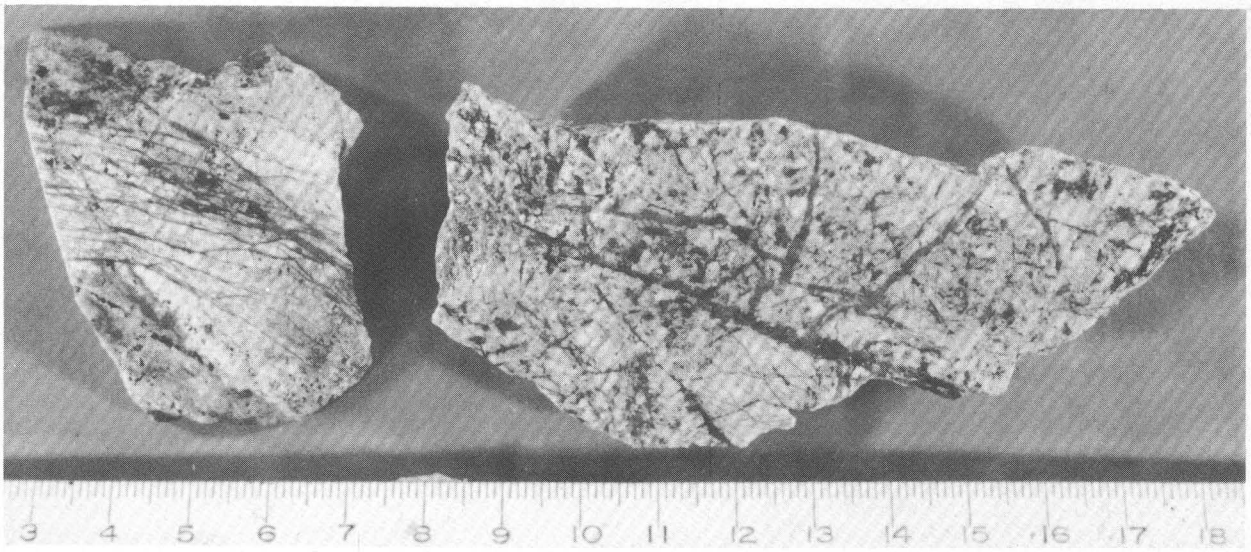

FIGURE 4.—Fractured and altered Middle Park Formation (left) and quartz latite porphyry (right) from inner altered zone. (Small-scale divisions are millimeters.)

At the surface most of the intensely altered rocks have been deeply weathered and leached. In particular, the pyrite-rich rocks on the ridge north of the stock have been extensively oxidized and now are stained or permeated by limonite. Sulfides are present only in the cores of large blocks or in the least permeable silicified rocks. The brightly colored red and yellow rocks of this ridge are perhaps the most striking evidence of the large area of rock alteration.

The general alteration pattern is modified locally along the northwest-trending fault northwest of the central stock, where the interstices of fault breccia are generally filled with limonite. In one place, at an altitude of about 9,980 feet, wavellite spherulites partially fill openings and cement the brecciated Middle Park sandstone. In a second locality, on the south side of Sheep Creek about 400 feet northeast of the contact between the Rabbit Ears Volcanics and the Middle Park Formation (fig. 2), several pits and two adits have been dug in altered Middle Park Formation. Workings are now caved and inaccessible. Ore samples collected from the dumps show abundant galena and resinous sphalerite in a matrix of sooty manganese oxides and iron oxides. These rocks were apparently mined from fracture fillings associated with porphyry dikes because the workings follow the surface trace of a major dike (fig. 2).

GEOCHEMICAL ANOMALIES

Semiquantitative spectrographic analyses of 24 samples from the hydrothermally altered area around the stock were made by Carl Forn and D. J. Grimes. Analyses of rocks from the inner zone of quartz-hematite-feldspar alteration (fig. 3) show the following ranges in metal content: Mo, 10–150 ppm; Cu, 15–50 ppm; Pb, 30–70 ppm. Analyses of rocks from the outer quartz-sericite-pyrite alteration assemblage show the following ranges in metal content: Mo, <3–10 ppm; Cu, 15–150 ppm; Pb, 10–300 ppm. Characteristically, the higher values of molybdenum were obtained from the silicified rocks near the stock, and the higher copper and lead values were obtained from sulfide-rich samples farther from the stock. Values for individual samples are not given here because they are highly dependent on the local differences in hypogene alteration and veining of the small grab samples and on the variable superposed effects of supergene alteration and leaching.

The effects of surficial leaching on most of these samples are probably large, but are difficult to evaluate. The oxidation of pyrite and the concomitant formation of sulfuric acid solutions in near-surface waters create an ideal environment for leaching of metals from sulfide-rich rocks. Evidence for this supergene leaching can be seen along Sheep Creek where springs fed from the area of pyritic alteration

enter the main stream. In the oxygenated reaches of the stream, its bed is covered by a flocculent limonite precipitate which tends to entrap other metals. Semiquantitative spectrographic analyses of iron-rich sediments from Sheep Creek and its minor tributaries in the area of hydrothermal alteration showed the following ranges in metal content: Mo, <3–70 ppm; Cu, 30–700 ppm; Pb, 30–500 ppm; Zn, <200–500 ppm. As much of the flocculent iron precipitate is removed by torrential flow during the spring runoff in this area of high stream gradient, most of this material accumulates during a single season. The limonitic material indicates active and continuing leaching of the pyritic rocks in this hydrothermally altered area.

SUMMARY

The Poison Ridge volcanic center of probable middle Tertiary age is marked by a composite quartz latite porphyry stock at the focus of a radiating dike swarm. It is surrounded by baked and hydrothermally altered rocks of the Middle Park Formation. An inner alteration zone is characterized by closely spaced and intersecting fractures filled with quartz-hematite-feldspar veinlets and by alteration of the rocks to pyrite, quartz, feldspar, muscovite, and biotite. An outer concentric zone of quartz-sericite-pyrite alteration extends as much as three quarters of a mile from the stock. Molybdenum concentrations are highest in rocks of the inner zone (Mo, 10–150 ppm), and copper and lead values are greatest in the outer zone (Cu, 15–150 ppm; Pb, 10–300 ppm). The intense fracturing of rocks in the inner zone and the dispersion of metals (sulfides) outward from this zone are favorable indications of potential ore. The zonal arrangement of potassic alteration minerals, with at least two distinct mineral assemblages, is similar to that found at many other intrusive centers associated with disseminated (porphyry type) ore deposits (Creasey, 1966). The shallow hypabyssal (subvolcanic) environment and the hypogene hematite of the inner zone suggest that ore would be most likely to occur at depths considerably below the present levels of exposure.

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