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THE USE OF GEOCHEMISTRY AT THE BALD BUTTE MOLYBDENITE PROSPECT, LEWIS AND CLARK COUNTY, MONTANA

O. H. Rostad

ABSTRACT

Geochemical soil sampling led to the discovery of interesting molybdenite mineralization associated with an unexposed porphryry intrusive. The area of interest is not marked by bleaching or limonitic dicoloration but is outlined by the 10-ppm Mo contour. The molybdenum anomaly as outlined by soil samples coincides well with anomalous molybdenum values in bedrock. The generally low-level anomalous values, most of which are under 100 ppm Mo, were obtained from the minus 35-mesh fraction of the soil samples.

A comparison of results from soil and rock samples indicates molybdenum leaching; whereas, under the slightly acid pH conditions prevailing, one would expect molybdenum values to be generally fixed in situ. On the basis of some laboratory test work, we suspect that this leaching is due to a shift in the molybdenum stability field caused by significant amounts of calcium.

This case history serves to illustrate that the merits of a prospect cannot be evaluated on the basis of geochemical values alone. It also points out the need for more knowledge of factors governing the geochemical mobility of molybdenum.

PURPOSE OF PAPER

The intent of this paper is twofold: first, to show that a low-level molybdenum anomaly may be interesting; and, second, that there is need for more work on the factors which affect the mobility of molybdenum in the weathering zone.

SETTING

The Bald Butte molybdenite prospect is about 28 miles by road northwesterly from Helena, Montana, and about 4 miles south of Marysville. It is on the south side of the topographic feature known as Bald Butte

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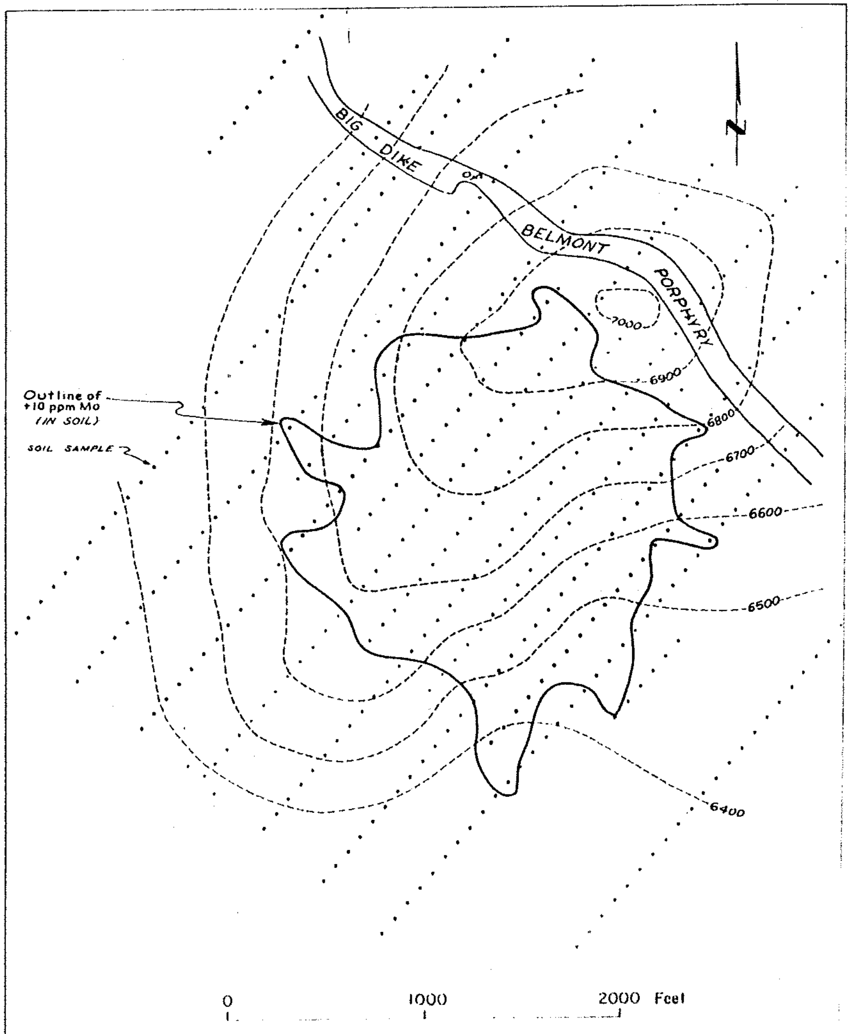

FIGURE 1 - TOPOGRAPHIC CONTOURS

between 6,300 and 7,000 feet above sea level (fig. 1). Mining activity in the Bald Butte portion of the Marysville mining district was almost exclusively for gold, principally in the Bald Butte gold mine.

The slopes on Bald Butte are generally quite rounded and covered with either timber or grass (fig. 2). Outcrop is limited to about 3 percent but

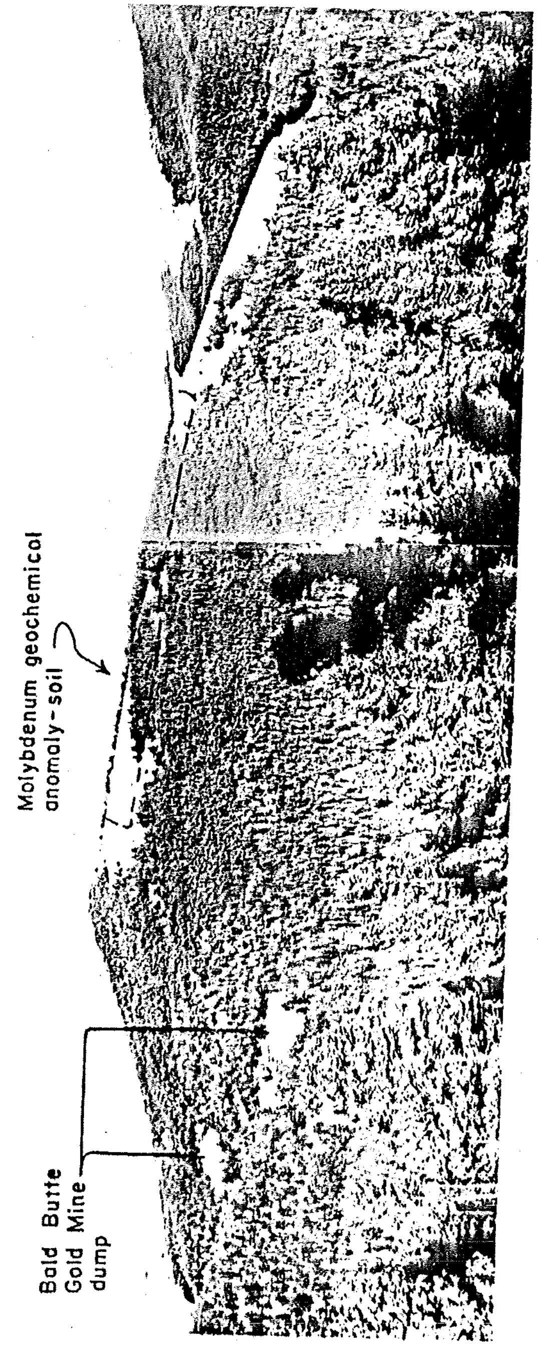

FIGURE 2. — Bald Butte as viewed from the west.

most of the exposures are outside the area anomalous in molybdenum. It should be noted that the area of interest is not visibly discolored by iron oxides.

GEOLOGY

In and near the area of interest on Bald Butte, three rock types are exposed. These are hornfels, irregular sills and dikes of microdiorite, and a major dike of Belmont diorite porphyry.

The hornfels is a dense, very fine-grained rock with light- to medium-green color bands that follow the original bedding. The hornfels was derived from impure dolomitic Helena limestone of the Precambrian Belt series and is considered to be the product of very strong metamorphism associated with the Marysville quartz diorite stock which was probably emplaced in Late Cretaceous or Early Tertiary time. Though not exposed on Bald Butte or immediate vicinity, the Marysville quartz diorite is inferred to underlie part of the nearby area at geologically shallow depths.

Microdiorite, so named by Barrell because of its fine-grained nature, comprises about 3 percent of the outcrop area exclusive of the Belmont porphyry. The microdiorite was intruded, predominantly as thin sills but also as narrow dikes, into relatively unaltered Precambrian Helena limestone probably in Cretaceous time. Metamorphism associated with the Marysville quartz diorite changed hornblende phenocrysts in the microdiorite to very fine-grained nests of hornblende. The microdiorite is not shown on the illustrations.

A dike of Belmont diorite porphyry, locally known as the "Big Dike," cuts both the hornfels and altered microdiorite on Bald Butte. This dike trends about N. 50° W. and dips 50°-60° SW.

The Big Dike is a major feature in the old Bald Butte gold mine, as the veins which were mined tended to follow fractures along the hanging and foot wall of the Big Dike. This mine worked relatively narrow, epithermal-type, vuggy quartz veins which contain calcite, fluorite, pyrite, and minor amounts of sphalerite, chalcopyrite, galena, and gold. Several veins of this type cut through the zone of molybdenum mineralization to the south, but they are notably lacking in gold and silver content in that zone. The relationships noted in core from the drill holes show that the epithermal veins are later than the molybdenite mineralization.

In and close to the molybdenum anomaly, the hornfels and microdiorite have been hydrothermally altered. The hornfels, originally rich in diopside, has been altered to a rock composed of hornblende, quartz, reddish-brown biotite, and K-feldspar, all of which are very fine grained. The resulting rock is usually dark greenish-black to brownish-black. The original bedding in the Precambrian rocks was preserved in the hornfels, but it has been obliterated by the later alteration.

GEOCHEMICAL EXPLORATION

Our interest in the area started when we noted a brief reference by Adolph Knopf (1913) to the presence of molybdenite in the Bald Butte gold mine. Knopf reported that molybdenite was associated with narrow quartz veinlets in the Big Dike, but he did not mention its presence in the country rock.

All of the mine workings were caved or in very poor condition; therefore, only the dumps and glory hole exposures were of any help to us. Even though evidence of molybdenite mineralization along the Big Dike was not impressive, we decided to undertake a geochemical soil survey to seek indications of a possible target area. The survey was laid out with parallel lines N.40° E., initially spaced at intervals of 400 feet. Samples were taken at slope intervals of 100 feet along the lines. The B horizon, which was usually encountered at depths of 8 to 18 inches, was sampled whenever possible. Additional lines were put in later at 200 foot spacings to help define the area of interest.

All soil samples were sieved, and the minus 35-mesh fraction from each was analyzed for molybdenum and copper by thiocyanate and biquinoline colorimetric methods, respectively, using fusion extractions.

On the basis of the frequency distribution, background for soil samples in this area is less than 2 ppm Mo. Accordingly, all values of 10 ppm Mo and higher were contoured as strongly anomalous (fig. 3). The results define a roughly circular area about 1,800 feet in diameter in which the molybdenum content of the soils is strongly anomalous. Of particular interest is the low level of the molybdenum anomaly.

The pH measurements were made on the minus 35-mesh fraction of the soil samples to obtain an idea whether molybdenum could be expected to be leached or fixed in the weathering zone. The range in pH values obtained from the soil samples is 5.1 to 7.1. The arithmetic average pH of all samples is slightly less than 6.1. The average pH of all samples from within the +10 ppm Mo isograd is 6.06 which is essentially the same as the over-all average. The distribution of samples with pH values of 6.0 or less and 6.1 or more is shown in figure 4, which illustrates that there is no apparent relationship between pH values and the molybdenum anomaly. The anomalous copper values shown in figure 5 appear to be directly related to the pH pattern as higher copper values are in the higher pH areas. The

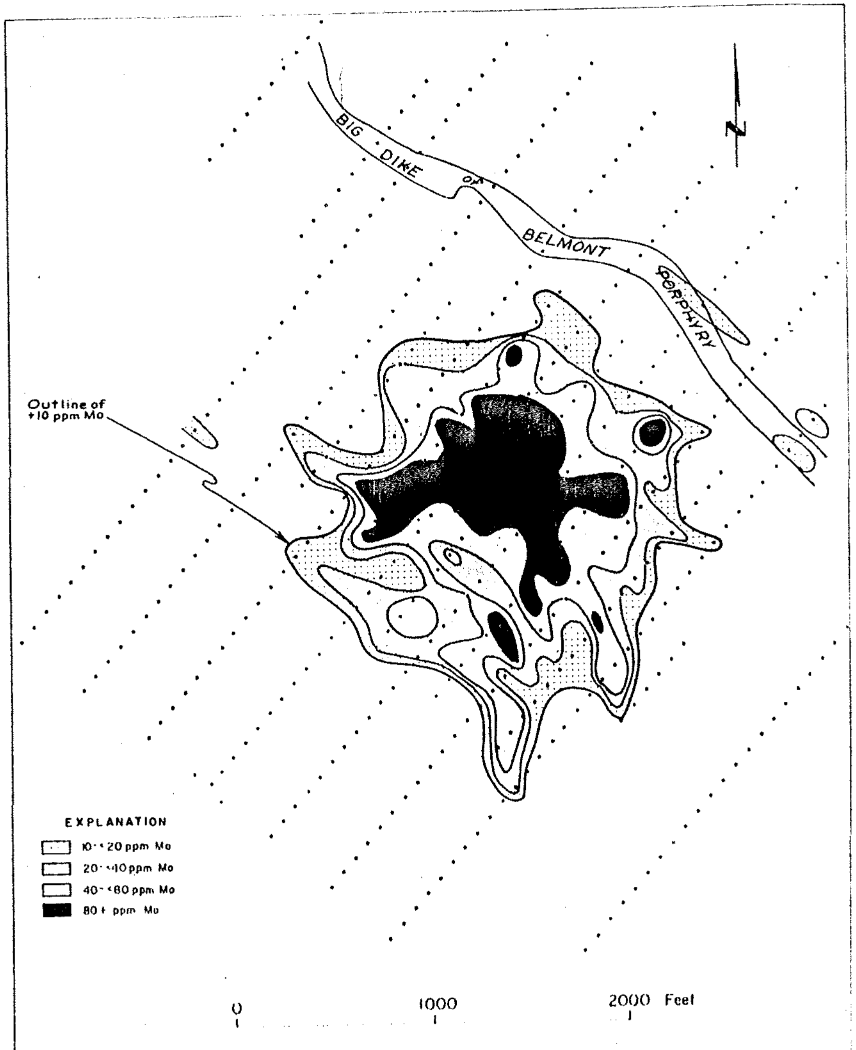

FIGURE 3- MOLYBDENUM GEOCHEMICAL ANOMALY- SOIL

copper distribution also reflects the presence of copper in epithermal veins along the Big Dike.

Selected samples of soil profiles are illustrated in figure 6. These show that the molybdenum values are concentrated to some extent in the A horizon in profiles 5 and 6; in the B horizon in profiles 1 and 4; and in the C horizon, just above bedrock, in profiles 2, 4, 6, and 7. The bedrock values are higher than the A or B horizon values in profiles 1 and 6 and lower

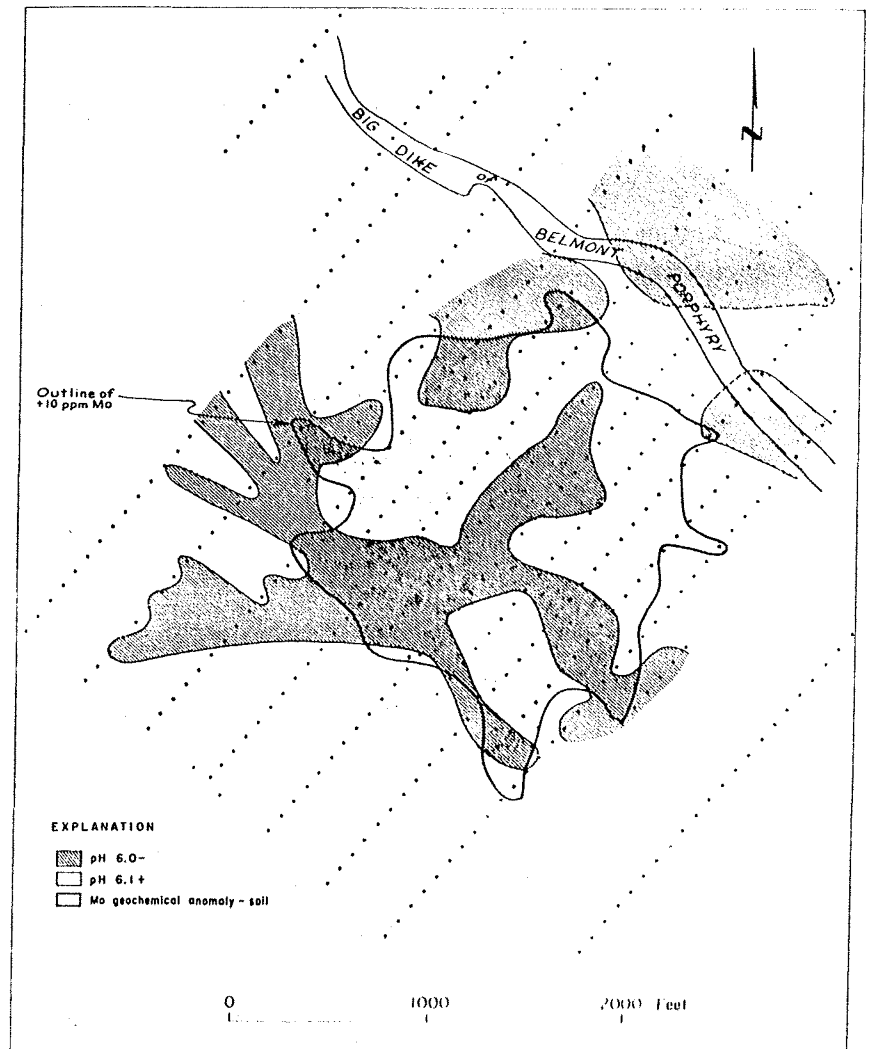

FIGURE 4- SOIL pH

in profiles 2, 3, 4, and 5; however, it should be remembered that the values being compared are rock against minus 35-mesh soil fraction.

Molybdenum has been somewhat mobile in the weathering zone at Bald Butte. This mobility is evidenced by general leaching of molybdenum from the soil and upper few feet of bedrock. Leaching has taken place in spite of the fact that the pH of the soil in much of the area is less than 6.0, the theoretical limit (according to Hansuld) below which most oxide molyb-

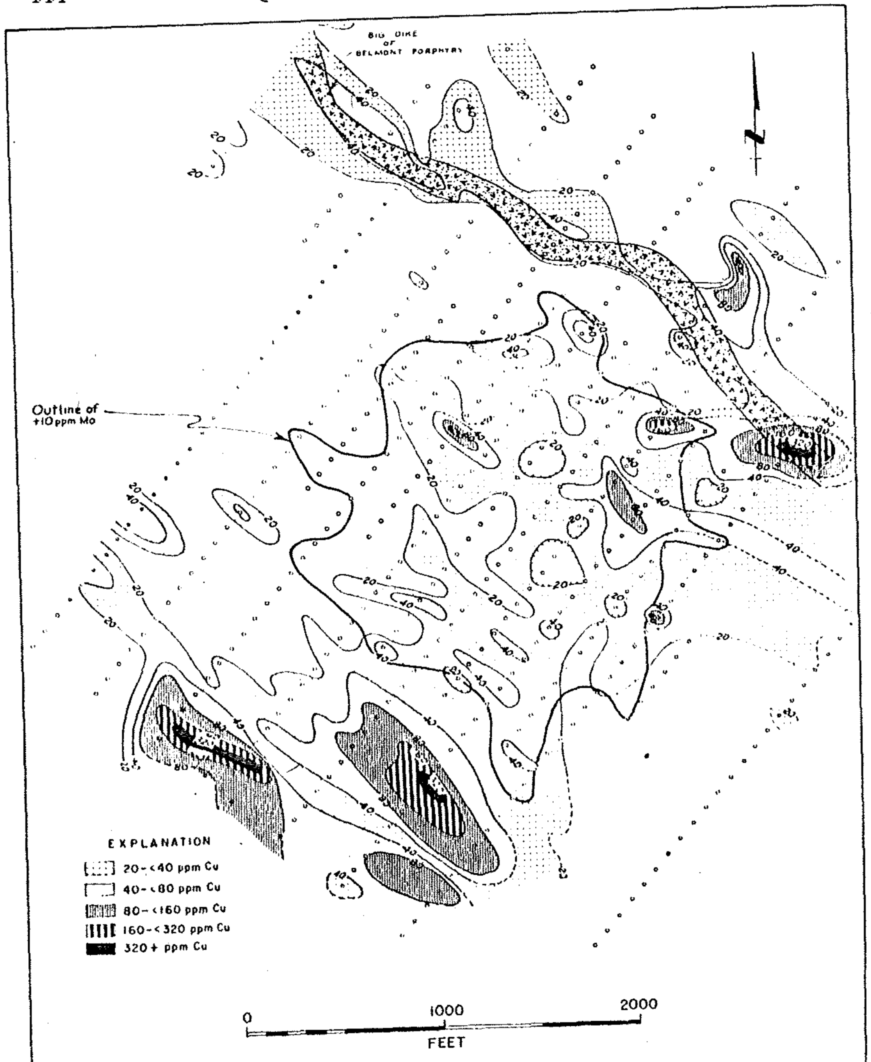

FIGURE 5- COPPER GEOCHEMICAL ANOMALY - SOIL

denum should be fixed. Molybdenum has apparently been fixed to some extent in areas where concentrations of iron oxides are found, particularly in the vicinity of sub-outcrops of epithermal veins. Values obtained from samples of the top few inches to 1 foot of bedrock were low—generally about half of the values obtained from the minus 35-mesh fraction of the soil samples. Some of the plus 35-mesh fractions were analyzed and found, as is commonly the case, to contain less molybdenum than the minus 35-mesh

FIGURE 6 - GEOCHEMICAL PROFILES - MOLYBDENUM

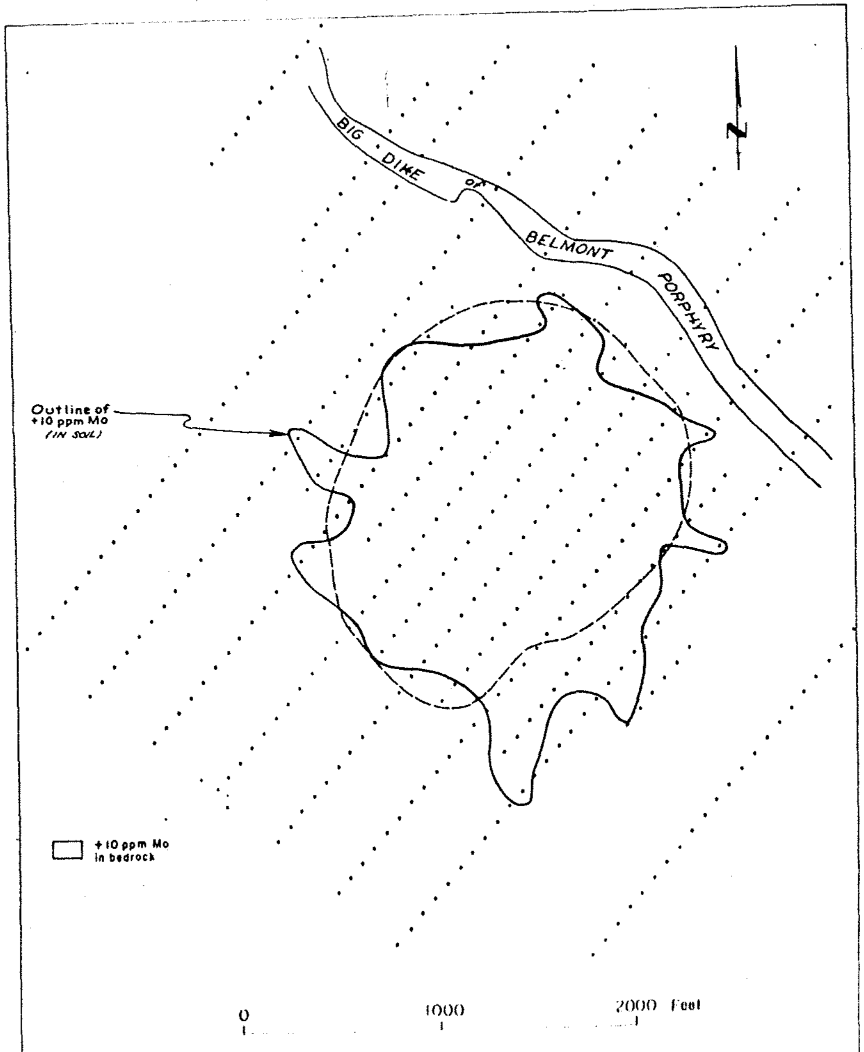

FIGURE 7 MOLYBDENUM ANOMALY IN BEDROCK

fractions. Unfortunately, we do not have the weight percentages of plus 35 and minus 35 mesh, but the whole soil samples will probably average somewhat less. The anomalous area as defined by samples of bedrock is shown in figure 7. In spite of the fact that molybdenum is being leached from the weathering zone, the areas defined by soil samples and bedrock samples are in close agreement; however, the bedrock anomaly is not as well defined because fewer rock samples were taken.

Noticeable weathering effects in the bedrock fade out quickly with depth. In general, there is only minimal oxidation below 20 feet, although limonite has been found on fracture surfaces at depths of over 200 feet. The values obtained from rock in the interval from 1 foot to 20 feet below the top of bedrock average about 6 times higher than the top few inches of bedrock.

Additional evidence supporting the idea that molybdenum is being leached from the weathering zone at Bald Butte is found in the water samples taken from drainages in the area. Definitely anomalous values, from 10 to 12 ppb, were obtained next to Bald Butte; however, these fall off fairly rapidly to 4 ppb at a distance of 2 miles downstream. The highest and, for the purposes of this discussion, the most significant value obtained was 6,000 ppb Mo from water with a pH of 7.1 draining out of an adit in the anomalous area. The water samples from the streams had pH values of 7.1 to 8.0 but average about 7.7.

Much of the rock in the area of interest has hairline veinlets of calcite which may be related to the period of gold mineralization. On the basis of some of our experimental work, we suspect that the apparent shift in the molybdenum stability field to lower pH conditions may be caused by calcium ions; however, more work is needed to quantify the effects that calcium and other ions, such as iron, have on the mobility of molybdenum.

A peculiarity of the results is that very few of the samples over or near the Big Dike were anomalous in molybdenum, even though the presence of molybdenite in this dike was the cause of our investigation. A possible explanation for this situation may be leaching promoted in part by a higher carbonate content in and near the major epithermal veins which are localized along the dike.

FOLLOWUP WORK

On the basis of: (1) the geochemical information, (2) the presence of molybdenite in randomly oriented veinlets in hydrothermally altered hornfels on some prospect dumps, (3) similar stockwork-type quartz veinlets in bedrock exposed by bulldozer cuts, and (4) the presence of numerous small fragments of similar-type vein quartz in the anomalous area, we postulated an unexposed intrusive under the anomalous area. We drilled the area and found that a quartz porphyry intrusive complex underlies the anomalous zone. Quartz porphyry was cut in one drill hole at a depth of 90 feet below surface. Even though the area has been mapped in detail, we know of no other place on Bald Butte where the quartz porphyry is closer to surface. The bulk of the intrusive lies at depths of 200 feet or more and is off-center relative to the molybdenum geochemical anomaly.

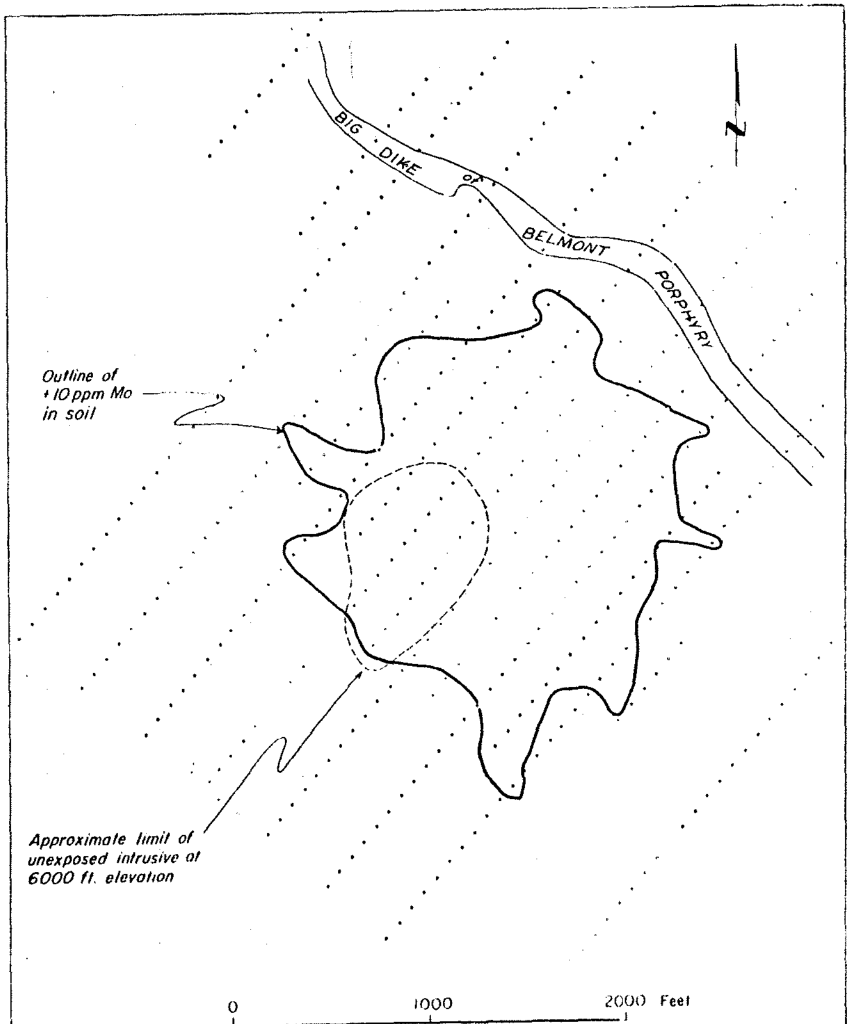

FIGURE 8-PLAN OF UNEXPOSED INTRUSIVE AT 6000 FT. ELEV.

The plan outline of the intrusive at 6,000 feet is shown in figure 8. Interesting molybdenite mineralization is closely associated and generally peripheral to the quartz porphyry intrusive; however, we consider the values encountered in our drilling to be low grade.

SUMMATION

In summation, points of interest are:

1. Soil sampling defined an area strongly anomalous in molybdenum content, though the lower limit defined as strongly anomalous is only 10 ppm Mo.
2. The molybdenum bedrock geochemical anomaly agrees closely in size and location with the soil anomaly even though some molybdenum is mobile in the weathering zone.
3. In spite of some pH conditions lower than 6.0, there has been leaching of molybdenum in the weathering zone, particularly in the top few inches to 1 foot of bedrock.
4. Some of our experimental work, conducted by J. A. Hansuld, indicates that the apparent shift in the molybdenum stability field to lower pH values is caused by calcium ions, but further work should be done.
5. We feel that geochemistry was our most useful tool in developing a picture of sufficient interest to justify drilling this prospect.

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