

# Geochemical Prospecting Studies in the Bullwhacker Mine Area, Eureka District Nevada

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## CONTRIBUTIONS TO GEOCHEMICAL PROSPECTING FOR MINERALS

### GEOCHEMICAL PROSPECTING STUDIES IN THE BULLWHACKER MINE AREA, EUREKA DISTRICT, NEVADA

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#### ABSTRACT

Investigation of the distribution of lead, zinc, and arsenic in soils of the Bullwhacker mine area, Eureka district, Nev., indicates dispersion patterns of these three metals in residual soils over near-surface ore at the Bullwhacker mine. Ore at greater depth in the shaft of the T. L. mine, however, is not reflected in lead, zinc, and arsenic contents of the soils.

The dispersion patterns are secondary residual soil anomalies in the classification given by H. E. Hawkes.

#### INTRODUCTION

This study was undertaken to determine whether geochemical prospecting methods which have proved valuable for finding ore in other districts can be successfully applied to exploration for new ore deposits in the Eureka district, Nevada. The ore deposits, which were mined as early as 1864 (Curtis, 1884, p. 3), have been valuable principally for their lead, silver, and gold.

The Bullwhacker mine area is on Mineral Point in the northern part of the Fish Creek Range, approximately 1½ miles northwest of the town of Eureka, Eureka County, Nev. (fig. 33). This area was selected for investigation because the distribution of ore in the area is relatively well known from drilling and mining.

James Prentice, under the supervision of T. S. Lovering, collected the samples for this study. All analyses were made by H. E. Crowe, of the U. S. Geological Survey.

#### GEOLOGY

The Bullwhacker mine area is underlain by a gently dipping sequence of sedimentary rocks of Cambrian and Ordovician age which have been intruded by a sill-like mass of quartz porphyry (fig. 34).

A general description of the sedimentary rocks is given in table 1.

A complete description of the sedimentary rocks in the vicinity of Eureka is given by Nolan and others (1956).

The general northeast dip of the sediments is interrupted to the west and the south by poorly defined domal upwarps, and numerous faults of relatively small throw cut the tilted and domed beds. The quartz porphyry appears to be younger than the faults.

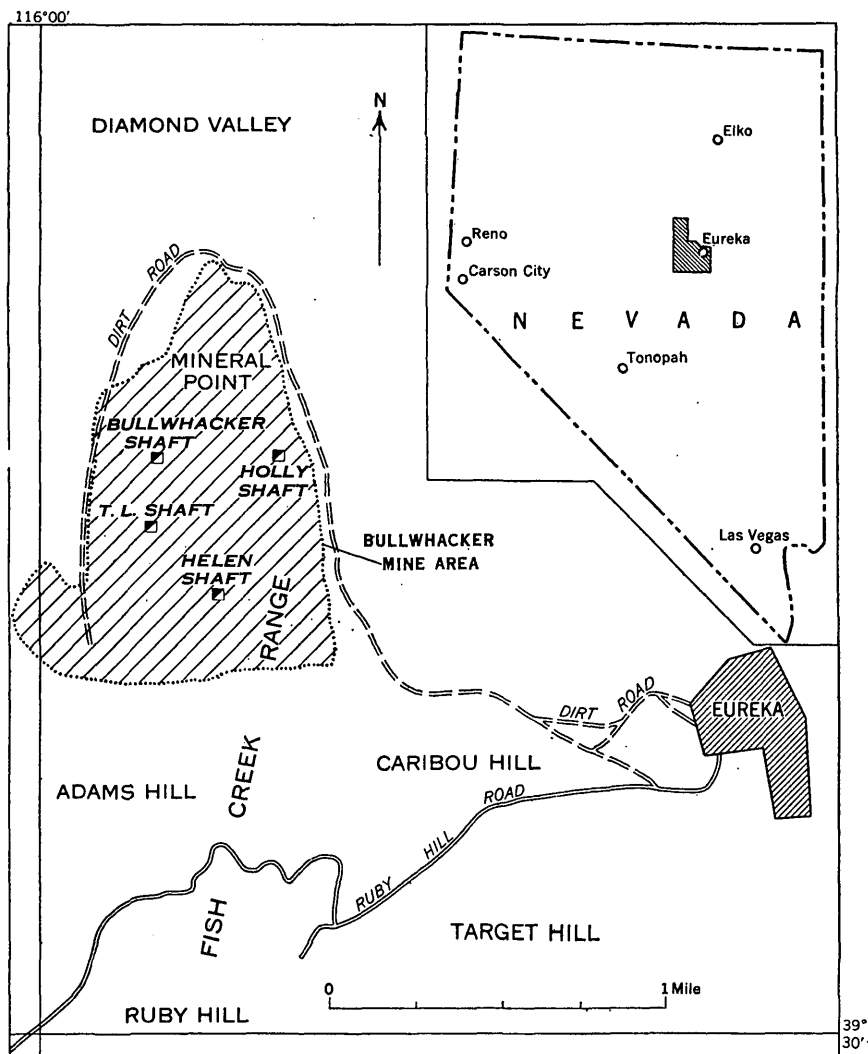


FIGURE 33.—Index map showing location of the Bullwhacker mine area (see fig. 34), Eureka district, Nevada.

The quartz porphyry forms an irregular sill-like mass over much of the area. It appears to have been intruded partly as a sill along the contact between the Dunderburg shale and the Windfall formation and partly as a dike along one or more of the faults that cut this contact. Information obtained by drilling, however, shows that its general habit is sill-like. Most of the rock is hydrothermally altered, and only the quartz phenocrysts remain unaltered. There has been little or no alteration of the invaded rocks.

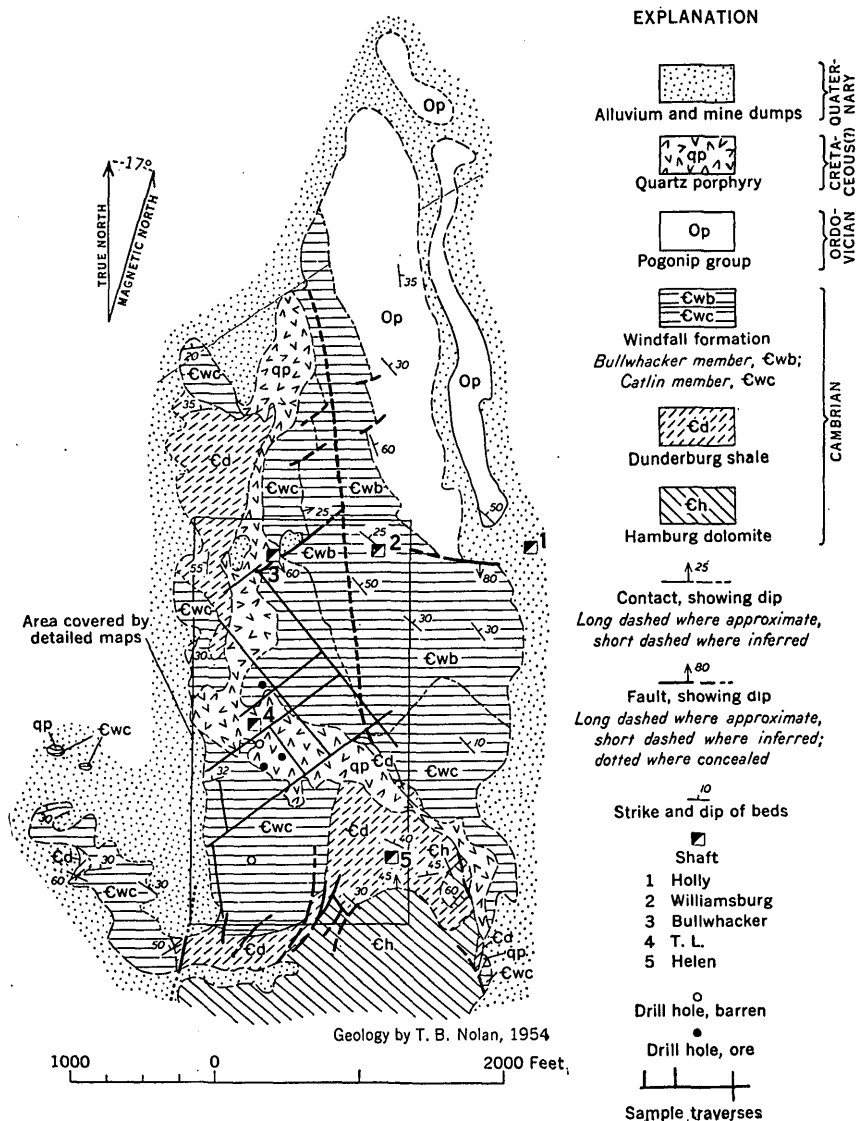


FIGURE 34.—Geologic map of the Bullwhacker mine area (see figs. 35, 36, 37).<sup>1</sup>Eureka district, Nevada.

The most conspicuous faults strike north-south, and are easily recognized by displacements of the contact of the Dunderburg shale and Windfall formation. Two eastward-trending fractures of relatively slight throw, however, appear to have been important in localizing the group of ore bodies between the Bullwhacker and Holly mines.

TABLE 1.—*Generalized descriptions of sedimentary rock units in the Bullwhacker mine area, Eureka district, Nevada*

Series	Rock unit		Thick- ness (feet)	Description
Lower Ordovician	Pogonip group		1,600	Thick-bedded limestone, mostly cherty
Upper Cambrian	Windfall formation	Bullwhacker member	400	Uniform thin-bedded sandy limestone. Ore bearing at Bullwhacker mine.
		Catlin member	250	Limestone with interbedded sandy or shaly limestone. Commonly cherty.
	Dunderburg shale		265±	Brown-weathering shale. Poorly exposed. Interbedded nodular and fossiliferous limestone.
Middle and Upper Cambrian	Hamburg dolomite		200+	Thick-bedded dark-gray dolomite. Thoroughly fractured in most places. Locally silicified, especially near contact with Dunderburg shale.

Although mineralized ground is widespread, as is reflected by the numerous prospect pits throughout the area, minable ore bodies in the area shown on figure 34 have been found only in the limestones of the Windfall formation and the Pogonip group near the surface in the belt from the Bullwhacker mine to the Holly mine and in a deeper zone that is near the base of the Hamburg dolomite in the vicinity of the T. L. shaft.

The ore bodies in the Bullwhacker and Holly mines are reported by Roland Blanchard (Oct. 1922, written communication) to be oxidized lead-silver-gold replacement bodies in limestone beds adjacent to steep crosscutting fissures, which were also mineralized. Although little of the ore remains to be seen, it is probable that it was in large part composed of plumbojarosite and other oxidized lead minerals and an abundance of "mineral" limonite. The ore bodies seem not to have extended more than a few tens of feet away from the fissures in the favorable limestone beds. These ore shoots were mined out many years ago.

Newly discovered ore shoots in the T. L. mine are also largely oxidized, though they lie from 200 to 400 feet below the ground-water table, which is about 635 feet below the surface. The ore shoots are irregular gently dipping lenses that are composed of pods and veinlike bodies of ore minerals in fractured dolomite. Some galena remains in the ore shoots, but anglesite, cerussite, plumbojarosite, and limonite appear to be the most abundant minerals.

The oxidized ore bodies at both the Bullwhacker and the T. L. mines are characterized by the presence of arsenic, probably in the mineral beudantite. They also contain small amounts of oxidized



zinc minerals. Sulfide ore cut by the workings in the T. L. mine contains pyrite, galena, sphalerite, and arsenopyrite.

### GEOCHEMICAL PROSPECTING SAMPLING METHOD

The samples collected for analysis in this study are soil grab samples and were taken at approximately 100-foot intervals along 4 major traverses and several minor traverses (figs. 34, 35, 36 and 37). The samples were taken from the upper 3 or 4 inches of the soil layer. The general flat surface of the Bullwhacker mine area suggests that transportation of soils has been minor. The soils sampled are largely residual.

The soil samples were taken without regard to parent material; hence, the sample traverses cross geologic boundaries separating limestone, shale, and quartz porphyry (fig. 34). No pronounced or consistent variation of metal content with type of parent material was

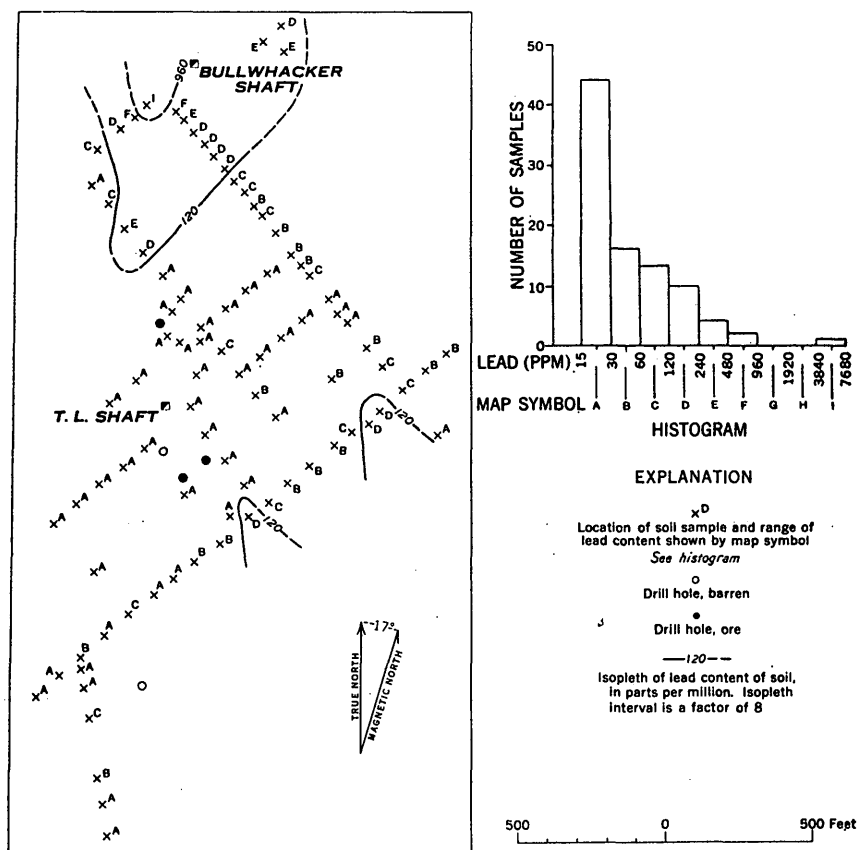


FIGURE 35.—Map and histogram showing the distribution of lead in soils of part of the Bullwhacker mine area, Eureka district, Nevada.

noted, though a consistent variation might be found using more precise analytical methods. At least, such variation is too minor to be detected with the type of analyses used for this investigation and is overshadowed by the magnitude of other variations that have been detected.

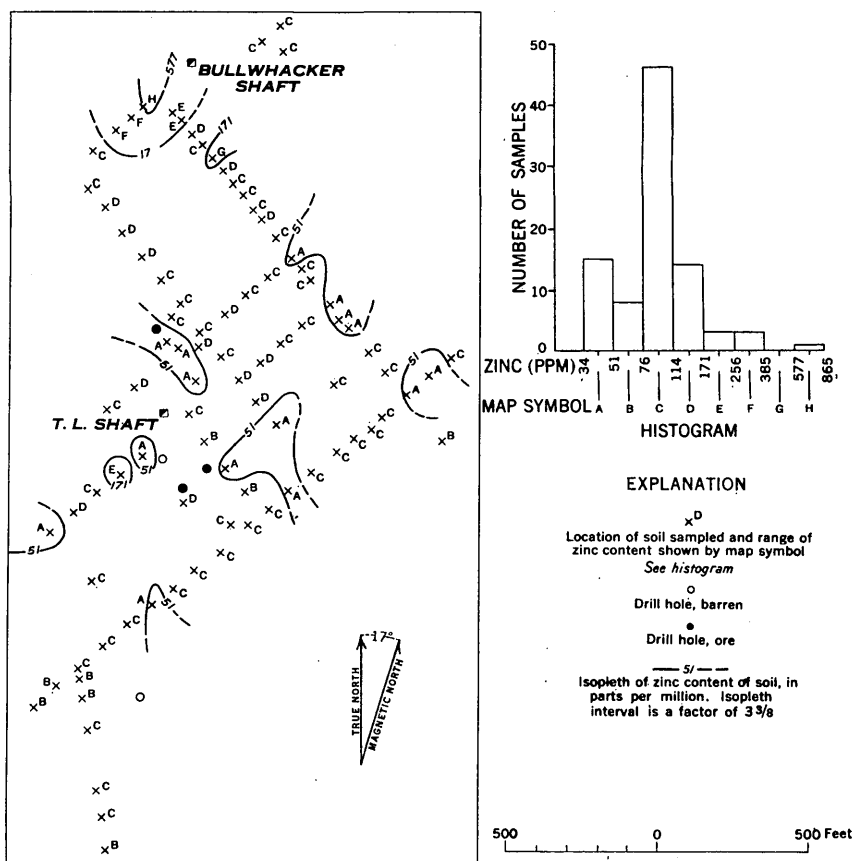


FIGURE 36.—Map and histogram showing the distribution of zinc in soils of part of the Bullwhacker mine area, Eureka district, Nevada.

### ANALYTICAL METHODS

The methods of lead, zinc, and arsenic determination used in this investigation were developed or modified for use in geochemical prospecting (Lakin and others, 1952, p. 14, 21; Almond, 1953, p. 8). Lead and zinc are determined using the heavy-metal reagent dithizone (Sandell, 1950, p. 87-111) in a carbon tetrachloride solution. Colors exhibited by the lead and zinc dithizonates in solution are compared visually with standard solutions. Up to 35 lead determinations or 60 zinc determinations can be made per man-day under favorable conditions.

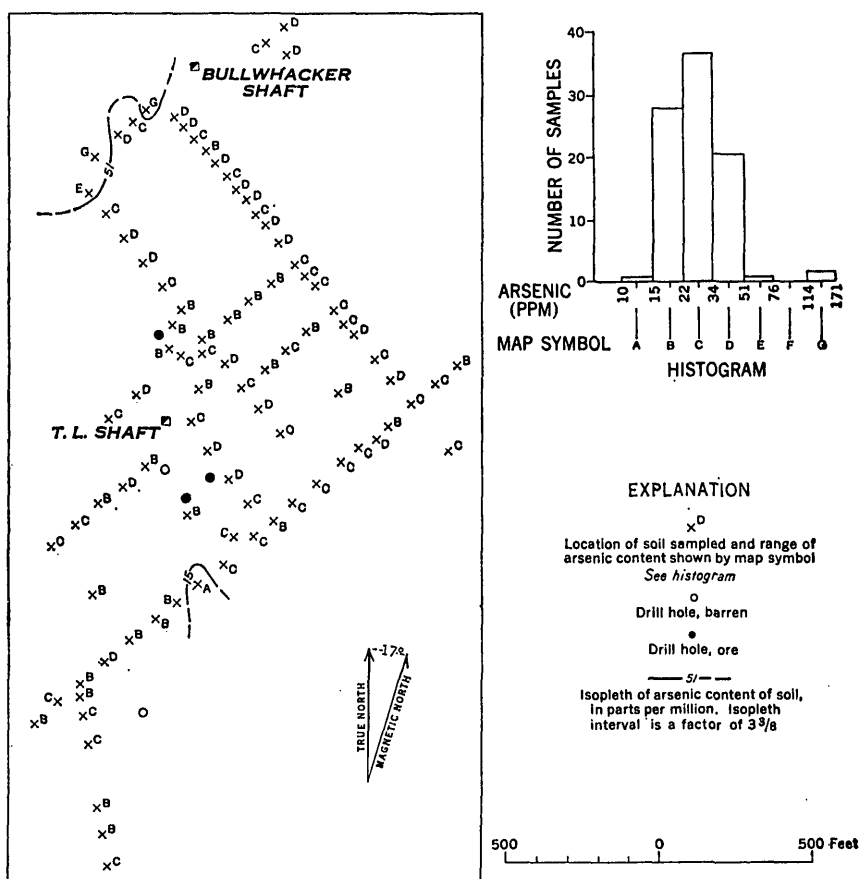


FIGURE 37.—Map and histogram showing the distribution of arsenic in soils of part of the Bullwhacker mine area, Eureka district, Nevada.

Arsenic is determined by the Gutzeit method involving the passage of gases evolved from an acidified sample solution through lead acetate to a confined spot on mercuric chloride paper. The color of the confined spot is compared visually with spots obtained from standard solutions.

Twenty-one samples from the Bullwhacker mine area were also analyzed for silver by a method described by Lakin and others (1952, p. 22). Some dispersion of silver in wallrock adjacent to ore in the Eureka district was reported by Curtis (1884, p. 82-87). The soil samples analyzed for this investigation, however, all contained less than 0.2 ppm (parts per million) silver. Many of the samples analyzed for silver were those highest in lead, zinc, and arsenic content.

## ANALYTICAL PRECISION

An estimate of the precision of the lead, zinc, and arsenic determinations may be obtained by examination of the two sets of replicate analyses given in table 2. The replicate analyses were made during the course of the other analytical work done for this report and by the same analyst. Approximately every eighth or ninth sample analyzed was a split of 1 of the 2 control samples. One large soil sample was split into two fractions by the analyst (samples 1 and 2, table 2). Sample 2 was then "salted" with high-grade oxidized lead ore. It is suspected that some of the variation between lead determinations on sample 2 may be due to incomplete mixing of the soil and lead ore mixture, through the arsenic and zinc determinations on this sample are in close agreement.

The total range of variation of replicate lead determinations is limited to three of the logarithmic classes used on the maps (fig. 35); the maximum spread is 4 times or 300 percent. However, determinations of lead in sample 1 which was not "salted" are in closer agreement. These determinations are limited to two of the log classes, and the maximum spread is only two and one-half times or 150 percent. The maximum deviation of lead determinations on sample 1 from the mean of the 9 replicate determinations is 60 percent.

TABLE 2.—*Replicate analyses of two soil samples by colorimetric methods (results in parts per million)*

[Values in parentheses are map symbols (figs. 35, 36, and 37) which are labels for logarithmic classes]

Sample 1			Sample 2		
Pb	As	Zn	Pb	As	Zn
200 (D)	200 (H)	100 (C)	25,000 (K)	300 (I)	1,500 (J)
120 (D)	40 (D)	50 (A)	30,000 (K)	300 (I)	1,500 (J)
100 (C)	60 (E)	100 (C)	15,000 (J)	500 (J)	1,200 (I)
150 (D)	50 (D)	50 (A)	15,000 (J)	400 (J)	1,000 (I)
100 (C)	20 (B)	50 (A)	40,000 (L)	500 (J)	1,000 (I)
100 (C)	60 (E)	50 (A)	60,000 (L)	500 (J)	1,000 (I)
200 (D)	60 (E)	100 (C)	20,000 (K)	400 (J)	1,000 (I)
80 (C)	50 (D)	100 (C)	15,000 (J)	300 (I)	1,300 (J)
100 (C)	40 (D)	70 (B)	15,000 (J)	400 (J)	1,500 (J)

The arsenic determinations agree generally within a factor of 1.7 except for 2 determinations of sample 1 which showed respectively 20 and 200 ppm arsenic in contrast to other determinations of 40–60 ppm. Except for these 2 determinations the results are limited to 2 adjoining log classes as used in figure 37.

Zinc determinations appear to be the most precise. The maximum deviation is two times or 100 percent. Zinc determinations of sample 2 are in even closer agreement.

In general, the variation of analytical determinations inherent in the analytical technique is limited to two log classes as used on figures 35, 36, and 37.

#### METHOD OF ANALYSIS OF ANALYTICAL DATA

The frequency distributions of lead, zinc, and arsenic are shown in the histograms of figures 35, 36, and 37, respectively. The class intervals of the histograms are logarithmic, the class limits forming geometric series generated by factors of 1.5 (Zn and As) and 2 (Pb). The class intervals of the zinc and arsenic histograms are less than that of lead because the total ranges of the concentrations of these elements in the samples are less than the lead range.

Figures 35, 36, and 37 also show, respectively, the map distribution patterns of lead, zinc, and arsenic in soils of the part of the Bullwhacker mine area that was sampled. The analytical results are plotted as symbols which identify the class interval of the histogram in which the concentration of the element in the sample occurs. Use of symbols rather than specific concentrations permits an easier visual examination of the distribution and variation of the data. The ranges of concentration specified by each map symbol are different for the three elements.

The areal variations or distribution patterns are also described by geometric isopleths.<sup>1</sup> The locations of the isopleths and the isopleth intervals were selected to show the more important features of the distribution patterns as exhibited by the map symbols.

#### RESULTS OF INVESTIGATION

Examination of figures 35, 36, and 37 indicates metal "highs" in the soils in the vicinity of the Bullwhacker shaft where lead-silver ore was mined just below the surface. It is conceivable that some part of each of these "highs" is the result of surface contamination from "ore dust" distributed during mining operations, but no evidence for this was noted in the field or in the samples. Calculation of the amount of lead in the upper 6 inches of soil within a 300-foot radius of the Bullwhacker shaft, using 0.025 percent as the average lead content indicates that it is comparable to the amount of lead in about 10 tons of 5 percent lead ore. Though some ore was undoubtedly distributed in the soils during mining operations, it appears reasonable to assume that it was far less than this amount and that the lead "high" in the soils around the shaft is due primarily to dispersion of lead into the wallrocks during ore formation and later concentration in the soils.

<sup>1</sup> Isopleth here means a line drawn through points of equal metal content.

The background concentration of lead in the soils which were sampled, regardless of type of parent material, appears to vary mostly between 15 and 120 ppm. It is important to note, however, that the term "background" cannot be interpreted here in the restricted sense that the samples are unaffected by mineralization (Lovering and others, 1956, p. 660). Most of them were taken too close to the known ore in the Bullwhacker shaft and other ore in the area to make this assumption safe. However, soils in the vicinity of the Bullwhacker shaft show a sharp rise in lead content over soils south of the shaft. The lead content of 1 sample collected 200 feet southwest of the shaft is more than 0.5 percent.

Two soil samples taken 700 feet east of the T. L. shaft contain lead in the range from 120 to 240 ppm. Lead concentrations in this range would not appear anomalous on the basis of the frequency distribution of all the lead analyses, but here they occur in adjacent samples taken near a shallow prospect pit in a weakly mineralized fault zone and are probably significant. In contrast, one lone value in this range southeast of the T. L. shaft is not considered significant.

The local background concentration of zinc in soils of the area ranges from 30 to 170 ppm. Soils taken from around the Bullwhacker shaft range up to 0.08 percent zinc. The two samples which were taken east of the T. L. shaft and which are regarded as anomalous in lead do not contain unusual concentrations of zinc.

Arsenic, in general, ranges from 15 to 50 ppm in samples taken more than several hundred feet from the Bullwhacker shaft. Samples taken nearer the shaft are as high as 150 ppm arsenic. The samples which were taken east of the T. L. shaft and which contain high concentrations of lead do not contain unusually high concentrations of arsenic.

The lead, zinc, and arsenic "highs" in the distribution patterns of these elements in soils near the Bullwhacker shaft appear clearly to be reflections of the ore and mineralized rock in the Bullwhacker mine. The greater intensity and broader extent of the lead "high" is in accord with the greater abundance of lead in the ore, but it also seems likely that during the processes of supergene alteration and oxidation of the country rock and during soil formation, lead was enriched in the soil by residual concentration while zinc, at least, was removed. In the Tintic district, Utah, Lovering (part I of Morris and Lovering, 1952, p. 697) has found that zinc traveled more than 150 feet during supergene alteration of the ore, while lead is practically immobile during supergene alteration. According to Lovering these relative mobilities agree with the relative solubilities of lead and zinc sulfate as given by Britton (1942). It has been suggested

by Goldschmidt (1954, p. 471) that arsenic is precipitated in soils by ferric iron hydroxide and that the arsenic is present in many soils as insoluble ferric arsenate.

From the relationships discussed above, notably the immobility of lead during supergene processes, it appears that dispersion of lead, zinc, and arsenic outward from the site of ore deposition took place during the emplacement of the ore, so that primary dispersion patterns of these elements are present in the country rock. The extent to which the primary pattern might differ from that found in the essentially residual soils could only be determined by sampling the unweathered bedrock beneath the thin soil cover. Regardless, lead, zinc, and arsenic are present in the soils in detectable amounts and exhibit secondary dispersion patterns or residual soil anomalies (Hawkes, 1954, p. 55).

In the writers' opinion the ore body at the Bullwhacker mine could have been discovered by the geochemical prospecting method used in this investigation. The metal "highs" near the Bullwhacker shaft are distinct and well pronounced for all three metals examined. On the other hand, the presence of the deeper ore in the T. L. shaft (800-1,000 feet below the surface) and the drill holes (800-1,100 feet below the surface) in the central part of the sampled area is not reflected in the distribution of the elements in the soils and could not have been detected.

A lead "high" in the soil south of a prospect pit in the southeastern part of the sampled area may be an indication of ore, although the weakly mineralized rock discovered in the pit was not encouraging. Additional geochemical prospecting along the fault crossing the prospect pit may indicate more pronounced metal anomalies related to the presence of ore.

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