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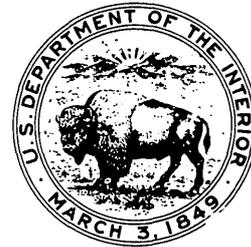
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Distribution of Gold and
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Near Ore Bodies in the
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Goldfield, Nevada

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GEOLOGICAL SURVEY PROFESSIONAL PAPER 843-A



Distribution of Gold and Other Ore-Related Elements Near Ore Bodies in the Oxidized Zone at Goldfield, Nevada

By R. P. ASHLEY and J. P. ALBERS

GEOLOGY AND GEOCHEMISTRY OF THE GOLDFIELD MINING DISTRICT, NEVADA

GEOLOGICAL SURVEY PROFESSIONAL PAPER 843-A

*An evaluation of nine elements for geochemical
prospecting in the hydrothermally altered area
at Goldfield*



UNITED STATES DEPARTMENT OF THE INTERIOR

ROGERS C. B. MORTON, *Secretary*

GEOLOGICAL SURVEY

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"Description of the shape of the Goldfield ore bodies is difficult because the ore bodies themselves are inherently vague."—F. L. Ransome, 1909.

**DISTRIBUTION OF GOLD AND OTHER ORE-RELATED
ELEMENTS NEAR ORE BODIES IN THE OXIDIZED ZONE
AT GOLDFIELD, NEVADA**

By R. P. ASHLEY and J. P. ALBERS

ABSTRACT

The heart of the Goldfield mining district occupies 0.5 square mile within a 15-square-mile area of hydrothermally altered Tertiary volcanic rocks. Most of the ore shoots were irregular bodies of epithermal bonanza ore within a few contiguous silicified zones enclosed in clay-bearing altered rocks. In 1966, 278 samples of argillized and silicified dacite were collected from excavations at the Combination and January mines, which once yielded gold in commercial quantities. Semiquantitative analyses show that gold, silver, lead, bismuth, mercury, and arsenic are notably enriched in rocks of the cuts. All these elements except lead and mercury formed conspicuous ore minerals. Geochemical maps and one geochemical profile across strike show that relatively high concentrations of all these elements are restricted to silicified zones. This low-tenor metallization dispersed through silicified zones does not extend into adjacent clay-bearing rocks. During oxidation, arsenic, copper, molybdenum, and zinc were leached from the silicified zones and the ore bodies within them, but these metals did not form distinct supergene halos in the surrounding argillized rocks. From the semiquantitative data available, the average amount of gold in silicified vein material is between 2 and 4 parts per million.

Geochemical sampling to detect relict hypogene dispersion patterns in Goldfield altered area, using oxidized rock samples, should be restricted to the silicified zones. If only a few samples are collected from each silicified zone, analysis for lead, of all the elements tested besides gold, is most likely to detect significant gold metallization, even though lead was only a minor constituent of the ores. Abundance of iron oxides is not a reliable guide to anomalous amounts of gold.

INTRODUCTION

This report discusses distributions of ore-related elements, particularly those closely associated with gold, in the oxidized part of a mined gold-bearing vein at Goldfield, Nev. The work described herein is part of a broader study treating the geology and geochemistry of hydrothermally altered rocks in the vicinity of Goldfield.

Most of the gold ore produced near Goldfield came from a 0.5-square-mile area immediately northeast of the town of Goldfield (figs. 1 and 2). This area will be

referred to as the "main district"; it is a small part of a 15-square-mile area of hydrothermally altered Tertiary volcanic rocks extending to the east and north, termed the "Goldfield altered area." The main district lies at the western margin of the Goldfield Hills, a group of peaks with maximum relief of about 1,200 feet, nearly surrounded by desert basins. Maximum relief in the main district is only 180 feet, with elevations ranging from 5,640 to 5,820 feet. The climate is arid; vegetation, sparse. U.S. Highway 95 passes through the town of Goldfield. An all-weather gravel road skirts the west and north sides of the main district, and several dirt roads traverse it.

In March 1966 the David-Goldfield Mining Corporation completed two deep exploratory cuts in the main district that provided most of the samples for this study. These opencuts lie just east of the Combination and January shafts along the vein system common to these two mines (pls. 1 and 2). The opencut walls, 15-20 feet high, expose many tunnels and stopes developed upward from the 80-foot level of the Combination mine, but the mine workings are almost completely inaccessible. Three months after excavation ceased, 278 samples for geochemical analysis were collected from the cut walls at 5-foot intervals. The cuts were mapped, and sample locations were determined by planetable methods. The planimetric maps of the cuts (pls. 2-4) do not show elevations and contours because the land surface around the cuts and the cut floors both have relatively little relief, whereas the intervening cut walls at the time of sampling and mapping were very steep, representing elevation changes between 15 and 50 feet along any given profile across the cut wall.

The main objective of this study is to identify indicator elements suitable for geochemical exploration for gold; each element must be evaluated with the fol-

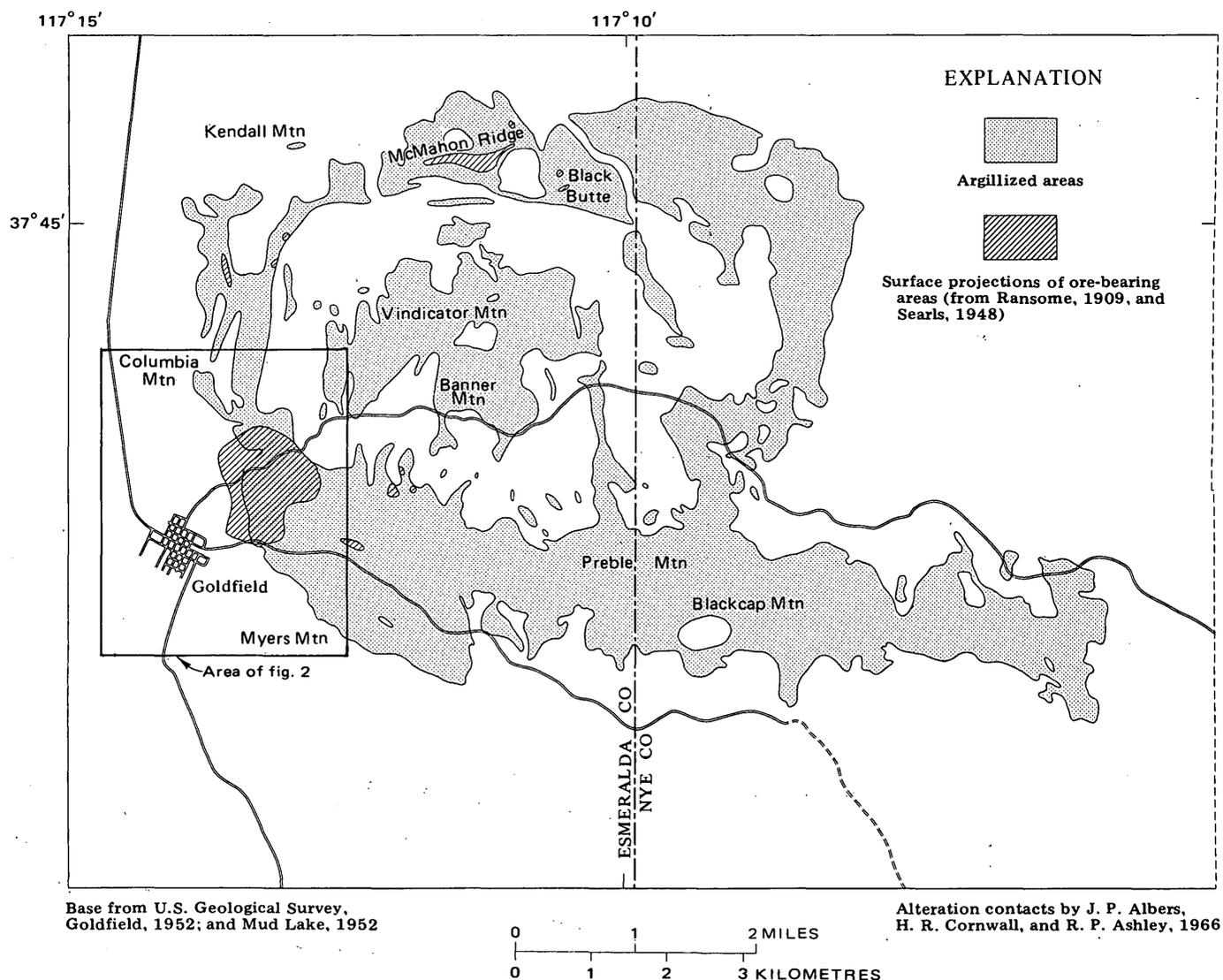


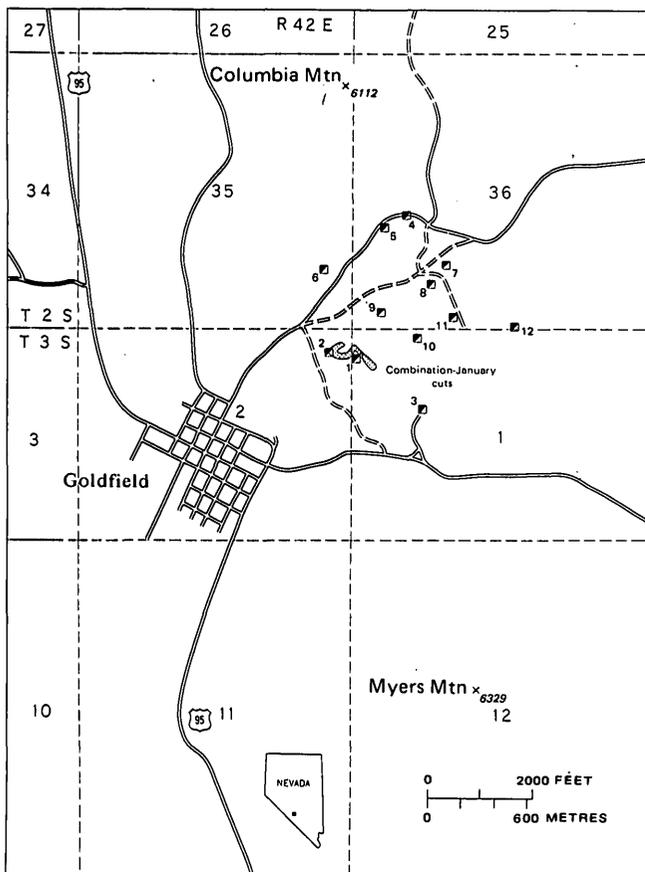
FIGURE 1.—Map of the Goldfield district showing areas of hydrothermal alteration and locations of ore deposits.

lowing requirements in mind. Ideally, amounts of an indicator element should correlate well with amounts of gold, and the range of values should be detectable by a reasonably inexpensive analytical procedure, with few samples falling below the detection threshold. Data also should be subject to less sampling error than gold data, and the element should form a dispersion aureole or halo larger than its associated economic gold deposit. These requirements imply that both the indicator element and gold were concentrated by the same processes. The 278 samples from the cuts and much smaller numbers of average-grade ore, high-grade ore, and unoxidized altered rock samples were studied to find indicator elements for gold.

Since a genetic relationship exists between hydrothermal alteration and ore deposition, the entire 15-square-mile altered area, which includes the main

district, has potential for new deposits. The Combination-January cuts expose oxidized altered and low-tenor metallized rocks, so data from them should show geochemical relations that will be found in bed-rock samples collected from the surface throughout the altered area.

Wilson (1944) evaluated several elements as indicators for gold in the Goldfield district. He showed that silver, bismuth, and tin are positively correlated with gold in the Goldfield Consolidated main vein on the 830-foot level of the Jumbo Extension mine (2,400 feet northeast of the Combination shaft, see fig. 2 and Searls, 1948, pl. 2). Although he did not find a clear relation between gold, silver, bismuth, and tin in and near the Clermont vein on the 225-foot level of the Clermont mine (2,000 feet northeast of the Combination shaft), or at two surface localities,



Base from U.S. Geological Survey, 1:62,500
Goldfield, 1952

FIGURE 2.—Map of Goldfield and vicinity showing the locations of major mines and the Combination-January cuts. 1, Combination mine. 2, January mine. 3, Florence mine. 4, Laguna mine. 5, Red Top mine. 6, Silver Pick mine. 7, Jumbo Extension mine. 8, Clermont mine. 9, Mokawk mine. 10, Jumbo mine. 11, Grizzly Bear mine. 12, Merger mine.

including one on the Jumbo vein (Jumbo mine, fig. 2, 1,200 feet east-northeast of the Combination shaft), Wilson concluded that bismuth and silver are promising indicator elements for gold. Since his samples yielding recognizable element correlations were entirely from unoxidized rocks, his results apply most directly to underground exploration. Except for preliminary results of this study (Ashley and Albers, 1969), no other reports concerning indicator elements for gold at Goldfield have been published.

The cooperation and assistance of Davis-Goldfield Mining Corporation, owner of the investigated ground, made this project possible. Most underground information on the Combination and January mines is from level maps compiled by Goldfield Consolidated Mines Corporation (unpub. data), now held by Davis-Goldfield Mining Corporation. Mr. M. G. Martin was particularly helpful in providing these maps. D. H. Whitebread and

L. D. Schultz of the U.S. Geological Survey assisted in geologic mapping and sampling of the cuts. The late Martin C. Duffy conducted us through the Florence mine; he allowed us to map and sample the limited workings still open, and he discussed with us the history of his mine. Mary E. Ashley coded the geochemical data for computer input.

GEOLOGIC SETTING

The geology of the Goldfield area has been described by Ransome (1909, 1910a, b), Locke (1912a, b), Searls (1948), Albers and Cornwall (1968), Albers and Kleinhampl (1970), and Ashley (1974). The main district is at the western margin of a Tertiary volcanic center composed of silicic and intermediate tuffs and volcanic breccias, and rhyolite, quartz latite, trachyandesite, and rhyodacite flows. These volcanic rocks cover Ordovician metasedimentary rocks and Mesozoic granitic rocks that crop out in many small inliers to the north and northeast of the main district.

The altered area and the position of the main district within it are shown in figure 1. At most localities the edge of the altered area shown in the figure represents the boundary between fresh rock and rock sufficiently argillized to be visibly bleached and locally stained with limonite. At some localities, such as at Blackcap Mountain (fig. 1), altered rocks are covered by younger unaltered volcanic rocks or alluvium; at these places the edge of the altered area is actually a contact with overlying materials rather than an alteration contact. Argillized rocks represent the bulk of the material within the altered area, but many silicified zones (veins) also appear, all of which are surrounded by argillized rocks. The silicified zones are localized along, and delineate, the faults and fractures that served as conduits for the hydrothermal fluids that produced the alteration. Along the south side of the area, from the main district through Preble Mountain and continuing to the east edge of the map area, these faults and fractures are very numerous and trend northwest to nearly east-west, with steep dips to both the north and south. Alteration in the central part of the area, in the vicinity of Vindicator and Banner Mountains, was controlled by northeast-trending, east-dipping shingle faults. The fault blocks dip west and are successively downdropped to the east. The west and north sides of the altered area are defined by a belt of altered rock that extends from the main district northward through Columbia Mountain to Kendall Mountain and then eastward through Black Butte. This belt delineates an arcuate structural pattern; most of the faults and fractures are aligned approximately parallel to the inner margin of the belt. Although the faults here do not dip consistently inward toward the Vindicator Mountain-Banner Mountain area, the arcuate pattern suggests that ring fracturing

occurred during the Tertiary volcanism, possibly accompanied by collapse, thereby forming a small caldera (see Albers and Kleinhampl, 1970; Ashley, 1974).

The ore deposits of the main district were irregular pipes and sheets within seven or eight vein systems composed of silicified rocks, striking north and dipping at moderate to low angles to the east. Dacite, andesite, and latite were altered to form these silicified zones and the argillized rocks that surround them.¹ The Combination-January, the westernmost of the major vein systems, is shown on level maps of the Combination mine (pl. 1). The first level of the mine was 80 feet below the shaft collar, at an elevation of 5,650 feet. Since the opencuts intersect workings that were reached from this level, a generalized geologic map of the cuts and adjacent surface has been substituted for the map of the first level. Early in the development of the properties, the workings of the Combination and January mines were joined; the Combination shaft serviced workings of the January throughout most of the history of production. Consequently, many workings of the January accord with those of the Combination, and different maps are not required for the two mines.

Dacite is the most widespread rock type in the two mines, occurring on all levels, but latite increases at the expense of dacite with increasing depth (pl. 1). Dacite rests directly on latite in the mine workings and abuts andesite just east of the mine workings. Latite, andesite, and dacite form a stratigraphic sequence from base to top 3 miles east of the town of Goldfield; in the Combination-January area the dacite either intrudes the andesite, as suggested by Ransome (1909, p. 79-81), or is interlayered with the andesite, as suggested by Searls (1948, p. 11, 12). Geologic mapping elsewhere in the Goldfield mining district indicates that Ransome's interpretation of the dacite as locally intrusive into the andesite and latite is more likely correct. Locally on the west side of the opencuts, as much as 15 feet of sedimentary breccia of the Siebert Tuff unconformably covers the hydrothermally altered volcanic rocks of the cuts (pl. 2). Mine dumps and 2-5 feet of alluvium cover much of the surface around the cuts (alluvium not shown on pl. 2). The positions of contacts shown on plate 1 are inferred where they are covered by these postalteration materials.

The most conspicuous feature of the Combination-January vein system is the abrupt change of strike at the January shaft from N. 60°-70° W. for the southern part of the system to N. 50°-65° E. for the northern part. The acute angle thus formed persists to the second (130-

foot) level but opens progressively on the third (180-foot), fourth (230-foot), and fifth (280-foot) levels and is not a notable feature on the sixth (380-foot) level (see pl. 1). The arcuate vein that passes through the January shaft at the surface and on the second level is nearly vertical at the shaft but dips northwest north of the shaft and northeast south of the shaft. In the vicinity of the shaft, the dip of the vein decreases below the second level, reaching 65° E. on the fourth level. The January shaft and the vein both continue to the fifth level, but these workings are not included on the Goldfield Consolidated Mines Corporation maps, so we do not know their full extent and have omitted them from plate 1. This western part of the vein system pinches out below the fifth (280-foot) level. The eastern part of the vein system dips steeply in the area east and south of the Combination shaft, but northwest of the shaft, on the inside or eastern side of the sharp bend, dips are 50°-30° E. decreasing with increasing depth.² The eastern and western parts of the vein system are close together near the surface, whereas separation is maximum at the fourth level. On the fifth and sixth levels all vein material shown belongs to the eastern part of the system, which continues to a maximum depth of 440 feet below the Combination shaft collar, corresponding to a minimum elevation of 5,290 feet. Most of the stoping was done from locations at the surface at elevations as high as 5,710 feet, to a point 330 feet below the Combination shaft collar, at an elevation of 5,400 feet. Ransome includes the western part of the vein system in his description of the January mine (1909, p. 216-220, pl. XVI) and includes the eastern part of the system in his description of the Combination mine (1909, p. 209-216, pls. XVII, XVIII).

The shapes and orientations of veins belonging to the Combination-January vein system are probably controlled mainly by prealteration fractures. Also, on the fourth, fifth, and sixth levels, some veins conform to the shape of the dacite-latite contact. (See discussions by Ransome, 1909, p. 211-212, 217-218, and Locke, 1912b, p. 844, on form of the Combination-January vein system.) At many localities the veins have been fractured and brecciated by postalteration movement, but in most places these displacements are too small to change the shapes of the veins significantly.

The Combination-January opencuts closely follow the Combination-January vein system (pls. 1 and 2), but they expose structures other than the veins themselves. A conspicuous structure seen in the cuts is the set of northeast-trending faults exposed 160 feet north-

¹The terms "dacite," "andesite," and "latite" are the names Ransome gave to the three volcanic units that dominate the Tertiary section in the main district. We retain Ransome's nomenclature for this report. By current volcanic rock classification systems (Rittmann, 1952; O'Connor, 1965), the dacite is a rhyodacite, the andesite includes both trachyandesite and rhyodacite flows, and the latite is a quartz latite.

²The ore bodies lying in the eastern part of the sharp bend had not yet been discovered at the time Ransome examined these mines. Consequently, we have no detailed information on the distribution of silicified rock in this part of the area. It is likely, however, that the eastern part of the vein system extends northwestward into this ground and that it includes these ore bodies.

west of the Combination shaft. Neither this set of faults, nor the parallel-trending but southeast-dipping fault located 320 feet west-northwest of the Combination shaft, can be definitely identified on the second level or deeper levels. Possibly, the dip of the northwest-dipping fault system progressively decreases with depth; if so, it could connect with the northeast-trending, 30°-northwest-dipping fault seen 250 feet northwest of the Combination shaft on the second level, and then die out at greater depth. The 140-foot-wide block between the two northeast-trending faults with opposing dips may be down dropped, offsetting the silicified zone segment between the faults to the west. Comparison of the map of the cuts with the maps for the second, third, and fourth levels suggests, however, that the silicified zone lying east of the conspicuous set of northeast-trending faults certainly must be part of the zone that passes near the Combination shaft, and that the silicified zone lying to the west of this set of faults certainly must be part of the zone that passes through or near the January shaft. Since these two silicified zones appear to be separate at depth, they are likely also to be separate at the level of exposure represented by the cuts, implying that only small displacements are associated with the northeast-trending faults.

ANALYTICAL METHODS

Gold values³ for samples from the Combination-January cuts were determined by atomic absorption spectrophotometry using hot hydrobromic acid extraction from 2-g samples (Huffman and others, 1967). Three other groups of samples were analyzed by the cold hydrobromic acid-bromine method of Thompson, Nakagawa, and VanSickle (1968). Tellurium and zinc concentrations were also determined by atomic absorption spectrophotometry (Nakagawa and Thompson, 1968; Ward and others, 1969, p. 20-22). Antimony concentrations were determined by a solution-colorimetric method, and arsenic concentrations by the Gutzeit-apparatus confined-spot colorimetric method (Ward and others, 1963, p. 38-44). Mercury concentrations were determined by the atomic absorption technique described by Vaughn and McCarthy (1964) and Vaughn (1967). All other elements, including silver, barium, beryllium, bismuth, cobalt, chromium, copper, lanthanum, manganese, molybdenum, niobium, nickel, lead, tin, strontium, vanadium, yttrium, iron, magnesium, calcium, and titanium were determined by six-step semiquantitative spectrographic analysis (Ward and others, 1963, p. 91-94; Grimes and Marranzino, 1968).

R. L. Miller, E. E. Martinez, F. Michaels, T. A. Roemer, J. A. Thomas, J. D. Mensik, W. D. Goss, G. T.

Burrow, G. D. Shipley, and C. Huffman carried out the gold analyses. The analysts for tellurium were H. D. King and E. E. Martinez; zinc, G. W. Dounay; antimony, H. D. King; arsenic, A. L. Meier, Z. Stephenson, and W. Campbell; mercury, W. W. Janes, J. James; S. Noble, J. G. Frisken, and W. Campbell. The spectrographic analyses were made by A. W. Helz, W. B. Crandell, J. L. Harris, H. W. Worthing, C. Heropoulos, H. Bastron, E. L. Mosier, J. M. Nishi, and J. L. Finley.

STATISTICAL METHODS

Element abundances⁴ were calculated using techniques described by Miesch (1967). Because frequency distributions for gold, mercury, arsenic, and zinc show moderate to strong positive skewness, the data were transformed to common logarithms of the concentration values; a better statistical estimate of abundance is possible if the frequency distribution is relatively symmetrical. All other elements were spectrographically determined, with geometric reporting intervals, making it mandatory to convert the data for these elements to common logarithms to provide statistics valid for comparison (see Miesch, 1967). The class intervals used for the gold, mercury, arsenic, and zinc histograms (pls. 3 and 4) were determined using a formula based on Sturges' rule (Sturges, 1926).⁵ For all other elements, class intervals are equivalent to the geometric reporting interval used in six-step spectrographic analysis: the sixth root of 10. Results are reported to the nearest number in the series 1, 0.7, 0.5, 0.3, 0.2, 0.15, 0.1, multiplied by an integral power of ten. Analytical error (one standard deviation) is approximately plus or minus one reporting interval.

In order to compare abundances of various elements in various data sets, relative abundances were calculated as follows. First, arithmetic means and standard deviations were computed for each element using all data (transformed to common logarithms) within the analytical detection limits. The antilogarithms of the means thus calculated are geometric means and the antilogarithms of the standard deviations are geometric deviations. Some elements have "censored" frequency distributions; that is, some fraction of the observations fall below the lower analytical detection limit or above the upper analytical detection limit. For these elements, logarithmic means are too high if the censored data falls below a minimum detection limit, or too low if the censored data falls above a maximum detection limit. Using Cohen's method (see Miesch, 1967; Cohen, 1959, 1961), these means and their associated

⁴"Abundance," as used in this report, means average concentration or weight proportion of an element in a given specimen or body of rock.

⁵ $C_i = \frac{MAX_i - MIN_i}{NM_i}$, where C_i is the class interval, or class size, MAX_i is the largest data value, MIN_i is the smallest data value, and NM_i is the number of classes. $NM_i = 2.5 + 1.442726 \ln(N_i)$, where N_i is the number of data values.

³The terms "value," "amount," and "concentration," as used in this report, mean quantity of an element expressed as weight per unit weight of rock. The specific units used in this report are percent and parts per million (ppm).

logarithmic standard deviations were revised. Cohen's method assumes that the data outside the censor point would, if known, complete a normal (in this study, log-normal) distribution when combined with the known part of the distribution. The revised logarithmic mean and logarithmic standard deviation calculated by the method are those of this ideal complete distribution. Use of Cohen's method for log-transformed data, therefore, assumes that the frequency distribution is log-normal. Many of the elements have frequency distributions that depart substantially from lognormal, but the method gives a satisfactory estimate of the logarithmic mean as long as the total distribution is unimodal. If more than 50 percent of the data for an element is censored, lognormality is a tenuous assumption. Then abundance estimates are not calculated, and the true abundance is assumed to be less than the detection threshold value (all such cases involve the lower detection limit). If geometric means or deviations for two data sets are claimed to be significantly different statistically, the difference between the logarithmic means or deviations was tested for significance at the 95-percent-confidence level (Moroney, 1956).

The abundance estimates derived by the above method are suitable for comparison, and they are used in figures accompanying the text. These estimates, however, are not the best possible estimates of true abundance because the geometric mean generally gives values somewhat smaller than the true abundance. To obtain the best possible estimate of true abundance, one must calculate Sichel's *t* estimator, a statistical measure of central tendency for lognormal frequency distributions, designed to eliminate the negative bias inherent in the geometric mean.⁶ The *t* estimator gives a value close to the arithmetic mean—but it is not so strongly influenced by relatively few very high values as the arithmetic mean. To obtain *t*, the geometric mean is multiplied by a correction factor approximately proportional in size to the geometric deviation but the correction factor is also partly determined by the number of samples (see discussion by Miesch, 1967, p. B7–B8). Sichel's *t* estimator was calculated for each element from the logarithmic mean and standard deviation previously calculated by Cohen's method. These values are included in table 4 for the interested reader, even though they are not used for the data comparisons upon which this study relies. Approximate confidence intervals for Sichel's *t* were calculated for gold by using an equation given by Aitchison and Brown (1963, p. 50).

Correlation coefficients were calculated for each pair of elements by computer using the log-transformed

data, although using the untransformed data would have produced the same results because we calculated Spearman's rank correlation coefficient rather than the more widely used product-moment correlation coefficient. Flanagan (1957) showed that the rank correlation coefficient is particularly suitable for semiquantitative spectrographic data and is the only valid method of computing a correlation coefficient between an element determined chemically and an element determined spectrographically. The Spearman rank correlation coefficient is nonparametric and therefore does not require the assumptions that must be made when using the product-moment correlation coefficient. These assumptions include a fundamentally normal distribution for each element, independence of successive data pairs, and homogeneity of variances. Since most of the elements investigated here were determined spectrographically, but several important elements were determined chemically, we have adopted Flanagan's method. Each correlation coefficient was calculated using only those observations having data within the detection limits for both elements involved. Since a different number of observations was used for nearly every correlation coefficient, the reliability of each coefficient is different. Each coefficient was subjected to a significance test, using Student's *t*. The correlation matrices (fig. 7) show which correlation coefficients are significant at the 99- and 95-percent confidence levels. Flanagan (1957) presents and explains the formulas for computing both the rank correlation coefficient and the significance test and gives references to the statistics literature that carries the derivations of these formulas. Additional explanation of rank correlation coefficients and the way in which we use results of the significance test are given later in this report (see section on "Correlation Matrices").

HYDROTHERMAL ALTERATION AND METALLIZATION

The Tertiary volcanic flows that occupied the Combination-January area were hydrothermally altered, metallized, and later oxidized to the depths now accessible. Hydrothermal alteration and metallization were related as follows. Strong fracture zones that cut the flows provided channelways for the hydrothermal solutions; the rocks in and adjacent to these fracture zones were silicified, and rocks farther from the fracture zones were argillized. According to Ransome (1909, p. 158), Locke (1912a, p. 800–801), and Collins (1907a, p. 398), ore was associated with silicified zones (veins), and little ore extended into surrounding argillized rocks. Changes in ore grade were often abrupt, but boundaries between ore and low-grade or barren rock were everywhere gradational over at least a few feet (Ransome, 1909, p. 213, 218; Collins, 1907b, p. 435). Hydrothermal

⁶The *t* estimator, developed by H. S. Sichel (1952, 1966), is not to be confused with Student's *t*, a frequency distribution function commonly used to calculate confidence intervals for various statistical measures. Sichel developed the *t* estimator for evaluating ore blocks in South African gold mines.

wallrock alteration was well advanced when metallization began, but some hydrothermal quartz formed contemporaneously with metal sulfides and gold and some alunite formed contemporaneously with metal sulfides, mainly pyrite (Ransome, 1909, p. 167, 169-170). Fracturing of the silicified ledges during the later stages of alteration produced local concentrations of gold and sulfides and provided relatively large open cavities in which rich ore formed. The bulk of the precious metal recovered, however, was apparently disseminated through volumes of rock within the silicified zones; most ore is therefore structurally controlled by prealteration fracturing (Ransome, 1909, p. 160-162). In the extensive barren parts of the Goldfield altered area, the silicified zones show structural relations and alteration mineral assemblages identical to those in metallized areas, so metals were deposited during and after wallrock alteration only where they were available to the hydrothermal system; presumably they entered the system at deeper levels.

The fault zones and shear zones shown on plate 2, although they probably do not represent large displacements, record movement that occurred after silicification developed along northwest-trending fractures. The shear zones consist of many closely spaced fractures, whereas fault zones consist of one or several large breaks with few subsidiary fractures. Much of the rock exposed in the cuts, both silicified and argillized, is moderately to intensely fractured; the fractures have diverse orientations and at many localities show slickensides representing movement in diverse directions. They are too small and too numerous to show on plate 2. In some of the shear zones and fault zones, clay minerals differ in abundance and proportion from adjacent argillized rocks; these facts suggest that these breaks formed before hydrothermal activity ceased. Supergene alteration could also be partly or wholly responsible for these differences in clay content, but we cannot rule out the possibility that at least some, or possibly all, of the postsilicification fault zones and shear zones originated before hydrothermal alteration and metallization ceased, even though some of these breaks and many small fractures show slickensides that must postdate all alteration.

All rock exposed in the cuts is within the upper part of the oxidized zone. The depth of oxidation at the Combination mine is 130-140 feet (Ransome, 1909, p. 177, 216), and water was found at 210 feet when the shaft was sunk (Collins, 1907a, p. 398). The depth of oxidation at the January mine is 180 feet, and the original water level was 160 feet (Ransome, 1909, pl. XVI, p. 187, 219).

To describe completely the petrographic changes produced by hydrothermal alteration, metallization, and oxidation, we should ideally have suites of unaltered

rocks, unoxidized argillized rocks, unoxidized silicified rocks, unoxidized average-grade ores, unoxidized high-grade ores, oxidized argillized rocks, oxidized silicified rocks, and oxidized average-grade and high-grade ores. We were able to obtain satisfactory numbers of all but three of these nine groups: unoxidized argillized rocks and oxidized average- and high-grade ores. The Combination-January cuts provided particularly large numbers of oxidized argillized and silicified rocks. Although some silicified rock samples from the cuts actually constitute average-grade ore, all high-grade oxidized ore has been mined out. The following sections describe the petrographic characteristics of unaltered dacite, the locations and petrographic characteristics of the unoxidized rocks, and the petrographic characteristics of the oxidized rocks. The petrographic descriptions in the latter section are more detailed because the number of oxidized samples available is much greater than the number of unoxidized samples. Though oxidation produces few mineralogic changes, it does produce some notable geochemical changes, which are discussed later in the report.

PETROGRAPHY OF UNALTERED DACITE SAMPLES

The Combination-January cuts mainly expose altered dacite. Since no samples were collected from the few small exposures of altered andesite, this section describes only the petrography of unaltered dacite, for comparison with the unoxidized and oxidized altered dacite samples to be described in following sections. Seventeen samples collected from scattered outcrops east of the main productive area provided geochemical data used later in the report. Thin sections for 3 of these 17 samples provided the following data.

The dacite is characterized by porphyritic texture, with 20-25 percent plagioclase phenocrysts 0.3-10 mm in diameter, about 2-6 percent each of biotite, hornblende, and augite phenocrysts as much as 2 mm long, 0.5-1 percent corroded quartz phenocrysts as much as 2 mm long, and 1 percent opaque grains 0.1-0.3 mm in diameter. The plagioclase phenocrysts show normal oscillatory zoning and have a bulk composition of about An₅₀. The groundmass is one-half to two-thirds microlites of sodic labradorite, a few percent minute opaque and mafic grains, and the remainder glass. The groundmass shows good pilotaxitic texture.

PETROGRAPHY OF UNOXIDIZED ALTERED ROCKS AND ORES

Sampling of unoxidized materials from the Combination-January area was not possible owing to lack of access and lack of ore samples. Thirteen unoxidized silicified dacite samples for petrographic and minor-element comparisons were collected from the Florence mine (fig. 3), 1,600 feet southeast of the Com-

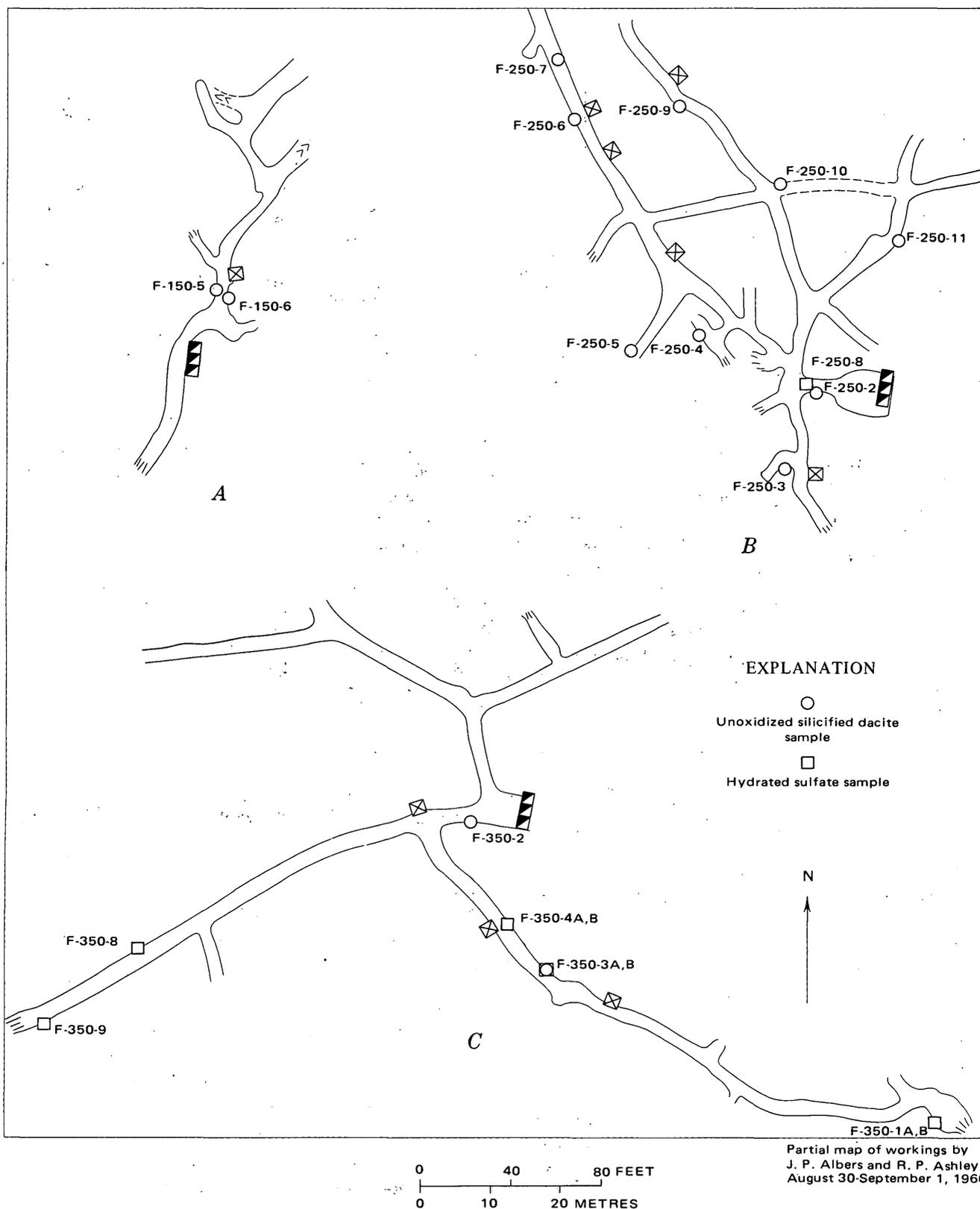
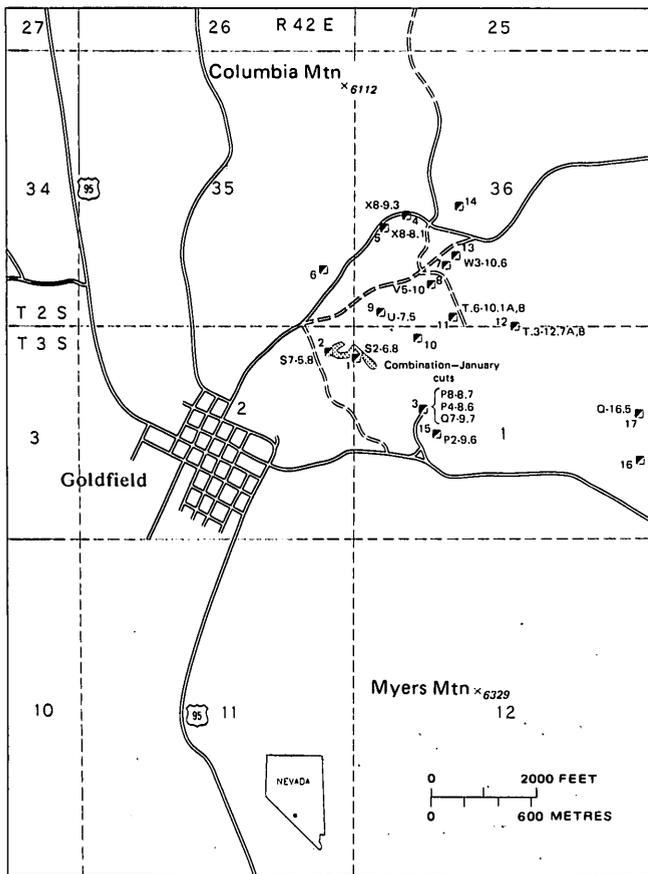


FIGURE 3.—Level maps of the Florence mine showing locations of unoxidized silicified dacite and hydrated sulfate samples. A, 150-foot level. B, 250-foot level. C, 350-foot level.



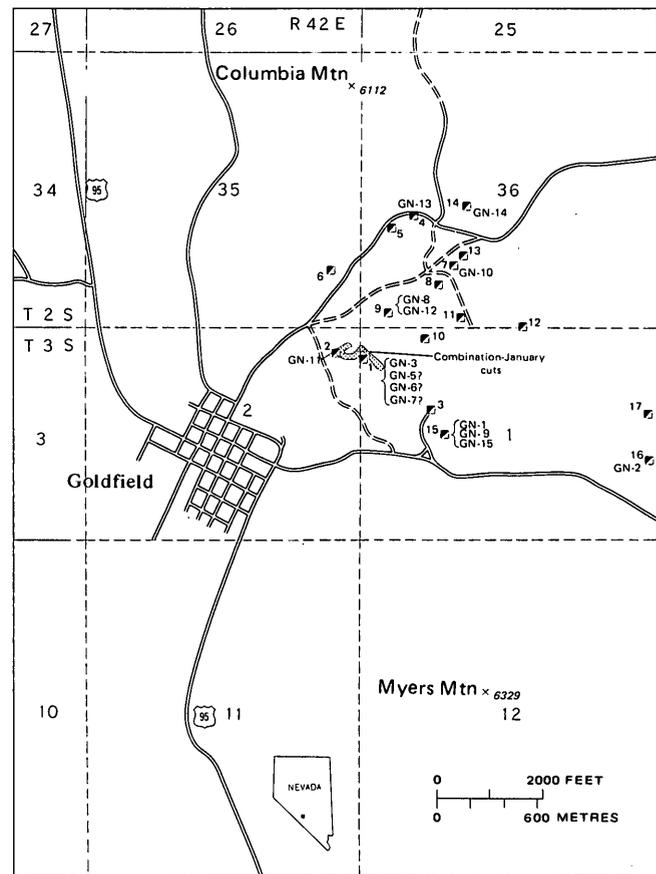
Base from U.S. Geological Survey, 1:62,500 Goldfield, 1952

FIGURE 4.—Map of Goldfield and vicinity showing locations of average-grade ore samples. Mines: 1, Combination. 2, January. 3, Florence. 4, Laguna. 5, Red Top. 6, Silver Pick. 7, Jumbo Extension. 8, Clermont. 9, Mohawk. 10, Jumbo. 11, Grizzly Bear. 12, Merger. 13, Velvet. 14, Kewanas. 15, Little Florence. 16, Gold Bar. 17, Deep Mines. (Has no recorded production (Searls, 1948, p. 18).)

ination mine, because the Florence is the only mine currently accessible. The Florence and the Combination vein systems probably connect. The 16 unoxidized average-grade ore samples are from mine dumps throughout the main district (fig. 4) and the 15 high-grade ores are from mines in several parts of the main district⁷ (fig. 5). Only two of the high-grade ore samples are unequivocally known to have come from the area under study. Three other high-grade samples most likely came from the Combination mine but could also have come from any one of the other major mines except the Florence.

In unoxidized silicified dacite, the groundmass and phenocrysts are both replaced by quartz, alunite, and kaolinite, but the phenocrysts are richer in alunite and kaolinite than the groundmass. Pyrite partly replaces former mafic minerals and is partly scattered through-

⁷High-grade ore samples loaned by U.S. National Museum of Natural History, Smithsonian Institution.



Base from U.S. Geological Survey, 1:62,500 Goldfield, 1952

FIGURE 5.—Map of Goldfield and vicinity showing locations of high-grade ore samples. Mines: 1, Combination. 2, January. 3, Florence. 4, Laguna. 5, Red Top. 6, Silver Pick. 7, Jumbo Extension. 8, Clermont. 9, Mohawk. 10, Jumbo. 11, Grizzly Bear. 12, Merger. 13, Velvet. 14, Kewanas. 15, Little Florence. 16, Gold Bear. 17, Deep Mines. (Has no recorded production.) Location of sample GN-4 unknown.

out the altered groundmass. The oxidized silicified rocks described in more detail in the next section are petrographically identical with these rocks, except that hematite or goethite replaces the pyrite. Unoxidized average-grade ores contain 10–25 percent sulfide-bearing quartz aggregates that form veinlets cutting the silicified wallrock or surrounding wallrock breccia fragments. Pyrite, famatinite, and other sulfides (see section on "Potential Indicator Elements") in these veinlets and fillings form crusts or are intergrown with the quartz. Considerable alunite accompanies the quartz in many veinlets, and kaolinite fills scattered vugs remaining at the centers of the veinlets. Much of the material in the veinlets filled open fractures or open breccias, but some specimens show metasomatic effects extending several millimeters from the vein margins into the silicified wallrocks. Otherwise, wallrocks in these specimens are identical to unmetallized

unoxidized silicified rocks; relict textures are generally well preserved. In a few specimens farnatinitite is disseminated through the silicified wallrock. In these relict textures are obliterated, indicating that metasomatism locally extends at least several centimetres from veins into wallrocks. The high-grade samples could be examined only visually; sulfide minerals are conspicuous in all samples and abundant in some. Native gold is visible in several. Details of ore mineralogy are presented in a later section.

PETROGRAPHY OF OXIDIZED ALTERED DACITE SAMPLES

The oxidized altered rocks exposed at the surface at Goldfield have been described in detail by Harvey and Vitaliano (1964). The criteria we use for classifying individual oxidized altered-rock samples from the Combination-January cuts are generally the same as the criteria they used for distinguishing several alteration zones and subzones. Thin sections from 30 of the samples from the cuts and X-ray diffractograms for 112 of the samples from the cuts provided the petrographic data that follow.

In this report we use the term "illite" to refer to a group of clay minerals that have (001) spacing approximately equal to 9.9 Å and that do not expand when treated with ethylene glycol. We do not distinguish between 1M and 2M polymorphic forms, both of which occur in these rocks. The term "kaolinite" refers to any member of the kaolinite group except halloysite (kaolinite, nacrite, dickite). We have not attempted precise identification of kaolinite-group minerals. The term "montmorillonite" refers to a group of expandable clay minerals having (001) spacing approximately equal to 14.7–15.5 Å (samples air dried.).

Soft clay-bearing altered rocks, although considered a single group for geochemical comparisons, are described here in two subgroups: those that contain montmorillonite, and those that do not. Montmorillonite-bearing rocks, restricted to a small area northwest of the Combination shaft (pl. 2), have plagioclase phenocrysts that are partly to almost completely altered to aggregates of 1–10 μm long illite and montmorillonite grains. Illite flakes and leucoxene granules replace biotite. Illite, leucoxene(?) or opaque minerals, and, in some samples, minor quartz replace hornblende and augite. The groundmass is an aggregate of 1–5 μm diameter quartz grains and 1–10 μm long montmorillonite, illite, and in some rocks kaolinite flakes. Crystals of jarosite 2–10 μm in diameter are scattered through the groundmass of some specimens. These rocks have undergone the weakest hydrothermal alteration of any rocks exposed in the cuts and were located farther from local sources of hydrothermal solutions than the other rocks described here. They belong

to the montmorillonite subzone of the argillic zone described by Harvey and Vitaliano (1964, p. 568).

Clay-bearing rocks with no montmorillonite contain abundant illite and varying amounts of kaolinite. In rocks with appreciable kaolinite, this mineral replaces the plagioclase phenocrysts with aggregates of crystals less than 3 μm to as much as 50 μm in diameter. In most rocks illite also occupies the plagioclase phenocrysts; the amount varies from a few flakes parallel to former crystallographic planes to 80 percent of the crystal. Biotite is replaced by illite and leucoxene; hornblende and augite are replaced by leucoxene, hematite, and minor quartz. The groundmass is an aggregate of 10 μm quartz grains with as much as 20 percent 1–5 μm illite and as much as 30 percent diffuse patches of very fine grained kaolinite. Scattered 1–5 μm granules of hematite, leucoxene, and in some rocks 10 μm jarosite or barite form about 10 percent of the groundmass. These clay-bearing rocks, which belong to the illite-kaolinite subzone of Harvey and Vitaliano (1964, p. 568–571), are the product of more intense hydrothermal alteration than the montmorillonite-bearing rocks.

The rocks mapped as silicified rocks constitute the second group of samples used for geochemical comparisons (pl. 2). They are microcrystalline quartz with 15–65 percent alunite and kaolinite. Most rocks contain alunite and kaolinite in proportions of 10:1 to 1:3, but some have no kaolinite. Typically, alunite and kaolinite together form about one-third of the rock. The rock, dense and hard, resembles chert because most of the alunite and kaolinite replaces former plagioclase phenocrysts or former biotite phenocrysts, and the groundmass is mostly fine-grained intergrown quartz. Samples with more than 50 percent alunite and kaolinite are relatively soft because these minerals become significant constituents of the groundmass; these rocks are indistinguishable in the field from alunite-free clay-bearing rocks. Twelve such samples, found locally at the margins of visibly silicified zones, are included with silicified rocks on plate 2. These alunite- and kaolinite-rich zones are always substantially thinner than the harder silicified zones adjacent to them. Former plagioclase phenocrysts in silicified rocks are represented by randomly oriented aggregates of 20 to 100 μm wide alunite plates with 25–80 percent quartz (10–50 μm) and kaolinite (2–10 μm). The groundmass is a 2–20 μm aggregate of quartz with 10–50 percent alunite or kaolinite or both (alunite generally more abundant), and scattered granules of hematite, leucoxene or rutile, and in some rocks, diaspore or jarosite. Subhedral areas containing 20–50 percent hematite, leucoxene or rutile, and rarely jarosite, but otherwise similar to the groundmass, represent biotite, hornblende, and augite phenocrysts. In some rocks, however,

biotite is the site of coarse platy alunite with 20–30 percent fine-grained leucosene or rutile, hematite, and minor quartz. The silicified rocks belong to the alunite-quartz zone of Harvey and Vitaliano (1964, p. 571). They form crudely tabular bodies that represent the rocks immediately adjacent to the fissures that conducted hydrothermal solutions.

All the altered rocks show moderately to well-preserved relict textures, regardless of intensity of alteration. Relict quartz phenocrysts remain in all samples.

POTENTIAL INDICATOR ELEMENTS: ELEMENTS ASSOCIATED WITH GOLD IN GOLDFIELD ORES

Published descriptions of the ores and comparisons between silicified rocks (13 samples), average-grade ores (16 samples), and high-grade ores (15 samples), all unoxidized, delineate the potential indicator elements associated with gold. Unoxidized ore typically contained pyrite (FeS_2), bismuthinite (Bi_2S_3), famatinite ($\text{Cu}_3(\text{Sb,As})\text{S}_4$)⁸, and native gold (Ransome, 1909, p. 110–119, 165–166, 170). Collins (1907a, p. 398) reported tetrahedrite($(\text{Cu,Fe})_{12}(\text{Sb,As})_4\text{S}_{13}$) and small quantities of chalcopyrite (CuFeS_2) and sphalerite (ZnS) from the unoxidized ores of the Combination mine. Ransome (1909, p. 216) reported telluride ore from the 280-foot level of the Combination (unoxidized ore). Tolman and Ambrose (1934, p. 264–278) reported marcasite (FeS_2), tennantite ($(\text{Cu,Fe})_{12}(\text{As,Sb})_4\text{S}_{13}$), goldfieldite ($\text{Cu}_3(\text{Te,Sb,As})\text{S}_4$)⁹, sylvanite (AgAuTe_4), hessite (Ag_2Te), and petzite ($(\text{Au,Ag})_2\text{Te}$) in ores from other mines in the vicinity. Searls (1948, p. 20) reported calaverite (AuTe_2) from a small vein developed by Newmont Mining Corporation about 0.3 mile west of the Florence mine. Ransome (1909, p. 112) described a few occurrences of galena (PbS). His analyses of ore from the Mohawk mine show copper, tellurium, bismuth, antimony, arsenic, gold, silver, zinc, and traces of lead (1909, p. 167, 169). X-ray diffraction and optical examination of the 16 average-grade ore samples¹⁰ confirm famatinite and subordinate tetrahedrite-tennantite, which is often enclosed in the famatinite. Polished sections show that small amounts of bismuthinite are commonly associated with tetrahedrite-tennantite. cursory examination of the 15 high-grade ores spec-

trographically analysed for this study revealed no new major ore minerals. Searls (1948, p. 18) reported minor but notable amounts of tin in ore from some of the deeper ore bodies of the district. Preliminary microprobe data obtained by G. K. Czamanske show that famatinite contains tin in variable amounts; concentrations of 0.5 percent tin are common, and a maximum of 2.7 percent tin was detected. No separate tin-bearing phase was recognized. A polished section of one of the average-grade ores provided this microprobe data and some additional microprobe data referred to later in the report. The ores were thus characterized by copper, antimony, arsenic, bismuth, tellurium, gold, silver, zinc, lead, and tin, in approximate order of decreasing absolute abundance. The economically important elements were gold, silver, copper, and lead, in order of decreasing total value of production.

Elements suitable for geochemical exploration must occur in notable amounts in ore-bearing silicified zones but not in barren silicified zones. To identify elements that were introduced mainly during metallization, rather than during silicification alone, we compared spectrographic data for unoxidized silicified rocks with similar data for unoxidized average-grade and high-grade ores. Analytical results and statistical data are given in tables 1 and 2, and the results are summarized in figure 6. Data for 17 samples of unaltered dacite are included for comparison with the altered and metallized rocks. The average minor-element content of these samples should be similar to that of the dacite in the Combination-January area before hydrothermal alteration. The samples comprising the three groups of unoxidized rocks and ores are few in number and from scattered localities, but they can be used for qualitative comparisons because the same alteration mineral assemblages occur throughout the district, and ore mineral assemblages from various parts of the district have significant features in common (Ransome, 1909, p. 165–169, 172–173). Unaltered dacite samples, unoxidized silicified dacite samples, unoxidized average-grade ores, and unoxidized high-grade ores form a sequence of four groups whose compositions show progressively stronger effects of the ore-forming process.

Copper dominates the ores, and antimony, arsenic, bismuth, tellurium, gold, silver, zinc, lead, and tin are relatively abundant (fig. 6), as is expected from available information on the ores. Data for tellurium are incomplete, but there is no reason to believe that amounts greater than 0.1 percent (1,000 ppm) occur in unaltered or unoxidized silicified dacite. In addition to the above elements, mercury and cadmium are relatively abundant. Molybdenum is moderately enriched in some ore samples, although the averages for molybdenum in the two groups of ores are not significantly larger than the

⁸Ransome (1909, p. 118–119) identified this mineral and presented an analysis showing the As:Sb ratio of the mineral to be nearly 1:1. Levy (1967) has shown that famatinite belongs to the tetragonal series luzonite-stibioluzonite and has suggested that the name famatinite be dropped. Our X-ray data, when compared with Levy's data, indicate that the Goldfield famatinite is the same as the material he prefers to call stibioluzonite. Skinner, Luce, and Makovicky (1972) prefer to retain the name famatinite, and we retain it here.

⁹Palache, Berman, and Frondel (1944) give the formula $\text{Cu}_3\text{Sb}_4\text{TeS}_{16}$. Thompson (1946) and, more recently, Levy (1967) consider goldfieldite to be a member of the tetrahedrite group. Levy gives the formula $\text{Cu}_3(\text{Te,Sb,As})\text{S}_4$.

¹⁰The ores examined contain approximately 0.1 to 2 ounces gold per ton and 0.1 to 6 ounces of silver per ton except for one sample bearing 30 ounces silver per ton. The average values for Goldfield, calculated using annual production figures for the most active period of the district, 1906 through 1918, are 0.99 ounce gold per ton and 0.34 ounce silver per ton (U.S. Geol. Survey, 1906–1918).

TABLE 1.—Analytical data for unaltered dacite, unoxidized

[L means less than the detection threshold shown in parentheses. N means not detected with the detection threshold shown]

Sample	Au	Ag	Pb	Bi	Hg	As	Cu	Zn	Mo	Sb	Sn	Te
17 unaltered												
AAG-662-----	L(0.02)	L(0.5)	20	L(10)	0.04	L(10)	L(2)	N(200)	L(2)			
682-----	L(0.02)	L(0.5)	10	L(10)	0.12	L(10)	30	N(200)	L(2)			
688-----	L(0.02)	L(0.5)	30	L(10)	0.18	L(10)	10	N(200)	L(2)			
722-----	L(0.02)	L(0.5)	10	L(10)	0.24	L(10)	2	N(200)	L(2)			
724-----	L(0.02)	L(0.5)	20	L(10)	0.10	L(10)	5	N(200)	L(2)			
773-----	0.02	L(0.5)	15	L(10)	n.d.	L(10)	5	N(200)	L(2)			
AAH-019-----	L(0.02)	L(0.5)	20	L(10)	0.03	L(10)	2	N(200)	L(2)			
AAG-987-----	L(0.02)	L(0.5)	20	L(10)	0.16	L(10)	5	N(200)	L(2)			
AAH-495-----	L(0.02)	L(0.5)	20	L(10)	0.10	L(10)	50	N(200)	L(2)			
ADQ-865-----	L(0.1)	N(0.5)	15	N(10)	0.05	L(10)	10	N(200)	N(3)			
869-----	L(0.1)	N(0.5)	10	N(10)	0.05	L(10)	15	N(200)	N(3)			
874-----	L(0.1)	N(0.5)	15	N(10)	0.04	L(10)	15	N(200)	N(3)			
895-----	L(0.1)	N(0.5)	15	N(10)	0.03	L(10)	20	N(200)	3			
942-----	L(0.1)	N(0.5)	15	N(10)	0.04	L(10)	20	N(200)	N(3)			
943-----	L(0.1)	N(0.5)	15	N(10)	0.03	L(10)	30	N(200)	3			
945-----	L(0.1)	N(0.5)	15	N(10)	L(0.01)	L(10)	30	N(200)	N(3)			
ADR-068-----	L(0.1)	N(0.5)	20	N(10)	0.07	L(10)	15	N(200)	N(3)			
13 unoxidized silicified dacite												
F-150-5-----	0.33	2	300	10	0.67	15	200	L(200)	L(2)	L(100)	L(20)	
6-----	0.39	L(0.5)	150	L(10)	0.30	30	100	L(200)	L(2)	L(100)	L(20)	
250-2-----	L(0.02)	0.5	70	L(10)	0.30	10	150	L(200)	2	L(100)	L(20)	
3-----	0.75	L(0.5)	10	15	1.25	10	150	L(200)	2	L(100)	L(20)	
4-----	4.32	L(0.5)	30	L(10)	0.42	5	70	L(200)	L(2)	L(100)	L(20)	
5-----	L(0.02)	L(0.5)	100	L(10)	0.80	10	100	L(200)	15	L(100)	L(20)	
6-----	1.79	5	300	200	1.05	10	300	200	L(2)	L(100)	L(20)	
7-----	1.11	20	70	1,000	10.4	320	G(5,000)	L(200)	15	700	200	
9-----	0.44	L(0.5)	300	L(10)	1.10	30	1,000	L(200)	2	L(100)	L(20)	
10-----	0.96	0.7	100	L(10)	0.33	5	100	L(200)	L(2)	L(100)	L(20)	
11-----	L(0.02)	L(0.5)	150	L(10)	0.24	20	500	L(200)	7	L(100)	L(20)	
350-2-----	0.05	L(0.5)	100	10	0.47	15	150	L(200)	2	L(100)	L(20)	
3B-----	L(0.02)	15	15	200	4.90	G(320)	2,000	L(200)	L(2)	700	30	
16 unoxidized average-												
57-5.8-----	70	100	300	1,500	G(6.0)	G(5,000)	30,000	L(200)	5	10,000	1,000	7,000
52-6.8-----	32	70	50	500	G(6.0)	3,000	10,000	L(200)	5	2,000	200	L(1,000)
T3-12.7A-----	3.0	20	200	50	2.7	G(5,000)	50,000	L(200)	10	3,000	700	L(1,000)
12.7B-----	4.0	20	100	200	0.26	200	10,000	700	15	700	10,000	L(1,000)
U-7.5-----	63	1,000	300	2,000	0.20	G(5,000)	20,000	L(200)	L(3)	2,000	50	30,000
Q-16.5-----	2.0	3	1,500	70	0.22	30	1,500	L(200)	3	L(100)	20	L(1,000)
P8-8.7-----	4.0	70	300	100	G(6.0)	G(5,000)	30,000	L(200)	L(3)	3,000	700	L(1,000)
X8-8.1-----	5.0	15	300	70	G(6.0)	1,000	10,000	3,000	L(3)	2,000	700	L(1,000)
P2-9.6-----	3.0	30	100	20	G(6.0)	5,000	10,000	L(200)	L(3)	700	150	L(1,000)
P4-8.6-----	1.0	5	300	30	0.38	100	300	L(200)	L(3)	L(100)	L(10)	L(1,000)
Q7-9.7-----	23	30	300	30	G(6.0)	4,000	15,000	L(200)	5	1,500	2,000	L(1,000)
X8-9.3-----	1.0	15	2,000	200	1.0	150	10,000	L(200)	5	200	10	L(1,000)
T6-10.1A-----	45	30	200	100	G(6.0)	150	10,000	L(200)	15	1,500	300	L(1,000)
10.1B-----	2.0	200	200	1,500	2.0	G(5,000)	70,000	L(200)	3	15,000	L(10)	7,000
V5-10-----	16	15	1,000	30	2.7	G(5,000)	10,000	L(200)	3	1,500	L(10)	L(1,000)
W3-10.6-----	10	100	2,000	500	3.5	G(5,000)	70,000	1,000	5	10,000	L(10)	L(1,000)
15 unoxidized high-												
GN-1-----	300	1,000	150	1.0	1,500	10	30	1,500	15	7.0	30,000	2.0
2-----	2,000	5,000	200	10	200	3	20	700	200	5.0	5,000	10
3-----	10,000	500	300	0.05	30	0.3	1.0	300	10	0.15	100	3.0
4-----	150	500	70	0.07	500	10	30	1,000	20	7.0	7,000	0.7
5-----	100	700	30	0.07	700	15	50	1,500	7	7.0	7,000	0.7
6-----	150	700	150	0.02	150	10	30	1,000	20	7.0	3,000	0.5
7-----	70	70	70	0.03	1,000	15	50	1,500	7	7.0	7,000	1.0
8-----	30,000	3,000	2,000	15	200	0.7	5.0	N(100)	N(2)	7.0	30	5.0
9-----	20,000	100	70	0.07	20	N(0.02)	0.05	N(100)	N(2)	0.007	N(7)	0.7
10-----	500	2,000	700	2.0	150	7	20	3,000	50	5.0	10,000	5.0
11-----	1,000	700	100	1.0	3,000	10	20	1,000	N(2)	7.0	7,000	5.0
12-----	7,000	20,000	1,500	10	150	N(0.02)	0.5	N(100)	N(2)	0.1	N(7)	3.0
13-----	200	300	2,000	10	500	2	5.0	20,000	5	1.5	5,000	0.3
14-----	50	1,000	50	0.5	N(20)	7	20	3,000	20	5.0	1,000	N(0.1)
15-----	20	10	30	0.01	50	N(0.02)	0.03	N(100)	N(2)	0.005	N(7)	N(0.1)

1. Fe, Mg, Ca, Ti in percent, all others in parts per million.

2. Bi, As, Cu, Sb, Te, and Fe in percent, all others in ppm.

average for unoxidized silicified dacite. These elements form a group subsequently referred to as "ore-related elements"; these are the elements to be investigated as geochemical indicators for the Goldfield deposits. Barely detectable amounts of palladium appeared in seven of the high-grade ore samples, and small but variable amounts of indium appeared in five of the high-grade ore samples. Detectable tungsten (200–300 ppm) appeared in two high-grade ore samples.

Platinum, tantalum, and thallium were sought by spectrographic analysis, but none of the samples from any data set contained detectable amounts of these elements. The only element not tested that might be important as an indicator is selenium. Ransome (1909, p. 134, 166) notes that selenium was found in tellurium-bearing oxidation products from two mines several miles northeast of the main district. Levy (1967, p. 131–132) notes an unidentified selenium-bearing mineral found as inclusions in goldfieldite.

silicified dacite, and ore samples from Goldfield

in parentheses. n.d.=not determined. G means greater than the upper detection limit shown in parentheses)

Cd	Ba	Be	Co	Cr	La	Mn	Nb	Ni	Sr	V	Y	Fe	Mg	Ca	Ti
dacite samples¹															
700		1	5	10	30	300	n.d.	5	700	100	20	3.0	1.0	1.0	0.3
2,000		1	50	20	30	1,500	n.d.	20	1,500	200	20	7.0	2.0	3.0	0.5
1,500	L(1)		15	30	70	500	n.d.	15	1,000	200	20	7.0	1.5	2.0	0.5
700		1	10	15	50	500	n.d.	15	700	200	20	3.0	1.0	1.0	0.2
1,000		1	L(5)	20	50	1,000	n.d.	10	1,000	100	20	5.0	1.0	2.0	0.3
700		1		7	20	500	n.d.	15	700	150	20	2.0	1.0	2.0	0.3
2,000	L(1)		10	30	50	700	n.d.	10	700	70	15	5.0	1.0	5.0	0.2
3,000		1	7	50	50	700	n.d.	15	700	200	15	7.0	1.5	5.0	0.7
1,500	L(1)		7	30	50	1,000	n.d.	7	1,500	150	15	10.0	2.0	3.0	0.7
1,500	N(1)		10	15	70	700		7	500	100	20	2.0	2.0	3.0	0.15
1,500	N(1)		10	20	70	700		15	700	150	30	2.0	1.5	1.5	0.2
1,500	N(1)		15	15	70	700		10	700	150	30	2.0	1.5	2.0	0.2
3,000	N(1)		15	30	70	700		10	1,500	200	30	3.0	1.5	3.0	0.5
1,500	N(1)		15	15	70	2,000		10	150	150	30	5.0	5.0	3.0	0.7
1,500		1	100	30	70	1,000		10	700	150	30	7.0	5.0	3.0	0.7
1,500	N(1)		20	30	70	2,000		10	1,500	200	30	7.0	5.0	7.0	0.7
2,000	N(1)		10	20	100	2,000		15	1,500	150	20	5.0	2.0	3.0	0.7
samples from the Florence mine¹															
5,000	L(1)	L(5)	50	30	70	n.d.	5	2,000	200	L(10)	2.0	0.07	0.07	1.0	
3,000	L(1)	L(5)	15	30	L(10)	n.d.	10	500	150	L(10)	2.0	0.02	0.2	0.7	
700	L(1)		10	30	50	n.d.	7	5,000	300	L(10)	5.0	0.15	0.2	0.7	
L(100)	L(1)		10	5	30	n.d.	10	L(100)	50	L(10)	5.0	0.15	0.05	0.7	
700	L(1)		5	15	30	n.d.	5	300	150	L(10)	3.0	L(0.02)	L(0.05)	0.7	
5,000	L(1)	150	70	30	100	n.d.	30	5,000	200	L(10)	10.0	0.07	0.15	0.5	
2,000	L(1)	500	10	20	50	n.d.	70	1,500	30	L(10)	7.0	0.2	L(0.05)	0.2	
1,000	L(1)	300	20	20	30	n.d.	50	700	70	L(10)	20.0	0.1	0.1	0.2	
5,000	L(1)	70	30	50	100	n.d.	30	1,500	200	L(10)	7.0	0.07	0.15	0.7	
300	L(1)	7	20	30	30	n.d.	7	1,000	150	L(10)	7.0	0.03	L(0.05)	0.3	
3,000	L(1)	150	15	50	100	n.d.	10	1,500	100	L(10)	5.0	0.2	0.1	0.5	
2,000	L(1)	10	30	50	70	n.d.	7	500	100	L(10)	7.0	0.03	0.15	0.5	
100	L(1)	L(5)	L(5)	20	30	n.d.	5	150	30	L(10)	1.0	L(0.02)	0.1	0.3	
grade ore samples¹															
200	L(1)	5	2	L(20)	10	L(10)	5	150	20	L(10)	5.0	0.005	0.07	0.07	
200	L(1)	10	7	L(20)	10	L(10)	20	70	20	L(10)	G(10)	0.002	0.03	0.07	
200	L(1)	7	5	L(20)	10	L(10)	15	100	30	10	7.0	L(0.002)	0.02	0.07	
70	L(1)	100	10	L(20)	5	L(10)	200	30	100	L(10)	G(10)	L(0.002)	0.015	0.15	
300	L(1)	5	15	L(20)	10	L(10)	10	150	70	L(10)	G(10)	0.005	0.03	0.2	
500	L(1)	10	7	L(20)	2	L(10)	50	100	30	L(10)	G(10)	L(0.002)	0.03	0.03	
300	L(1)	10	3	L(20)	10	L(10)	30	200	20	L(10)	G(10)	0.005	0.03	0.1	
500	L(1)	5	15	L(20)	15	L(10)	5	500	150	L(10)	3.0	0.007	0.05	0.15	
300	L(1)	5	5	L(20)	7	10	10	150	70	L(10)	3.0	0.005	0.05	0.15	
500	L(1)	5	2	L(20)	15	10	10	150	15	L(10)	3.0	0.015	0.07	0.07	
500	L(1)	7	15	L(20)	10	L(10)	10	200	70	L(10)	2.0	L(0.02)	0.1	0.15	
500	L(1)	7	5	L(20)	15	L(10)	50	300	30	L(10)	G(10)	L(0.02)	0.1	0.03	
150	L(1)	15	3	L(20)	7	L(10)	30	30	15	L(10)	G(10)	L(0.02)	0.015	0.03	
200	L(1)	15	3	L(20)	5	L(10)	10	100	30	L(10)	1.5	L(0.02)	0.02	0.1	
150	L(1)	15	3	L(20)	7	L(10)	30	700	70	L(10)	7.0	L(0.02)	0.05	0.03	
300	L(1)	10	5	30	1	L(10)	15	200	100	L(10)	5.0	L(0.02)	0.03	0.07	
grade ore samples^{2 3}															
700	50	N(1)	100	3	N(30)	50	N(7)	50	20	50	N(10)	0.2	15	50	100
100	7	N(1)	3	7	N(30)	1	N(7)	1.5	N(5)	70	N(10)	0.2	2	L(7)	30
N(50)	700	N(1)	10	10	N(30)	7	N(7)	10	500	50	N(10)	1.0	20	500	1,000
300	70	N(1)	15	5	N(30)	10	N(7)	15	70	100	N(10)	1.0	15	70	150
500	15	N(1)	150	N(1)	N(30)	2	N(7)	100	10	50	N(10)	0.7	5	L(7)	70
700	150	N(1)	15	3	N(30)	3	N(7)	10	100	70	N(10)	1.0	5	50	300
700	30	N(1)	20	2	N(30)	L(1)	N(7)	15	15	100	N(10)	0.7	3	7	150
300	30	N(1)	N(2)	1	N(30)	1	N(7)	20	N(3)	N(10)	0.1	3	20	150	
N(50)	100	N(1)	7	5	N(30)	5	10	1.5	150	30	N(10)	0.7	30	200	2,000
200	20	N(1)	30	10	N(30)	N(1)	N(7)	7	100	200	N(10)	1.5	10	20	30
150	2	N(1)	N(2)	3	N(30)	10	N(7)	2	N(5)	20	N(10)	0.02	2	7	10
150	2	N(1)	N(2)	1.5	N(30)	N(1)	N(7)	N(1)	N(5)	N(3)	N(10)	0.02	L(2)	L(7)	10
700	300	N(1)	15	10	30	N(1)	N(7)	20	700	70	N(10)	3.0	20	500	1,500
N(50)	20	N(1)	100	2	N(30)	5	N(7)	70	70	50	N(10)	7.0	50	30	20
N(50)	500	N(1)	15	7	N(30)	7	N(7)	3	700	70	10	1.5	50	2,000	2,000

3. All data obtained by six-step semiquantitative spectrographic analysis. Spectra of 10-fold and 100-fold dilutions were also recorded to evaluate better those elements occurring at high concentrations. Special exposure parameters were used to obtain the values for Hg.

The diagrams for iron, cobalt, chromium, nickel, and vanadium (fig. 6) are notably different from those for the elements described above. With regard to iron, unoxidized silicified dacite samples bear pyrite, much of which replaces former mafic minerals. Since the iron of this pyrite probably came from the preexisting mafic minerals, it is reasonable that unaltered and unoxidized silicified dacite have comparable amounts of iron, even though their mineral assemblages are vastly dif-

ferent. Some average-grade ore samples have pyrite associated with quartz veins and open-cavity fillings, in addition to that which replaces former mafic minerals in the silicified wallrock, producing iron contents notably greater than those seen in unoxidized silicified dacite samples. The average iron content, however, is not significantly larger than that calculated for unoxidized silicified rocks. High-grade ore samples, on the other hand, have much hematite and other ore minerals but

GEOLOGY AND GEOCHEMISTRY OF THE GOLDFIELD MINING DISTRICT, NEVADA

TABLE 2.—Statistical data for unaltered dacite, unoxidized silicified dacite, and ore samples.

[(G) indicates percentage of samples above an upper detection limit. Otherwise, percentage given is the number of samples below a lower detection limit. —, not calculated]

Element	Detection limit, log percent (ppm)	Percent samples outside detection limit	Logarithmic mean, log percent	Logarithmic standard deviation, log percent	Cohen's mean, log percent	Cohen's standard deviation, log percent	Geometric mean, ppm or percent (noted)	Geometric deviation
17 unaltered dacite samples								
Au	-5.70(0.02)	94	—	—	—	—	—	—
Ag	² -4.42(0.5)	100	—	—	—	—	—	—
Pb	—	0	-2.8	0.1	—	—	15	1.3
Bi	-3.08(10)	100	—	—	—	—	—	—
Hg ³	-6.00(0.01)	6	-5.2	0.3	-5.2	0.4	0.06	2.4
As	-3.00(10)	100	—	—	—	—	—	—
Cu	-3.75(2)	6	-2.9	0.4	-3.0	0.5	10	3.0
Zn	-1.75(200)	100	—	—	—	—	—	—
Mo	-3.75(2)	88	—	—	—	—	—	—
Ba	—	0	-0.8	0.2	—	—	1500	1.5
Be	-4.08(1)	59	—	—	—	—	—	—
Co	-3.42(5)	6	-2.9	0.3	-2.9	0.4	10	2.3
Cr	—	0	-2.7	0.2	—	—	20	1.5
La	—	0	-2.2	0.1	—	—	50	1.4
Mn	—	0	-1.1	0.2	—	—	700	1.7
Nb ⁴	—	0	-3.0	0.1	—	—	10	1.1
Ni	—	0	-2.9	0.2	—	—	15	1.7
Sr	—	0	-1.0	0.2	—	—	1000	1.4
V	—	0	-1.8	0.1	—	—	150	1.4
Y	—	0	-2.7	0.1	—	—	20	1.3
Fe	—	0	0.6	0.2	—	—	5%	1.7
Mg	—	0	0.3	0.2	—	—	2%	1.7
Ca	—	0	0.4	0.2	—	—	2%	1.7
Ti	—	0	-0.4	0.3	—	—	0.5%	1.8
13 unoxidized silicified dacite samples from the Florence mine								
Au	-5.70(0.02)	31	-4.2	0.5	-4.9	1.1	0.14	13.2
Ag	-4.42(0.5)	54	-3.5	0.6	4.4	1.1	0.5	11.4
Pb	—	0	-2.1	0.5	—	—	100	2.9
Bi	-3.08(10)	54	-2.2	0.8	-3.2	1.2	7	15.0
Hg	—	0	-4.1	0.5	—	—	0.80	2.9
As	-1.50(320)	58	-2.8	0.5	-2.7	0.6	20	4.1
Cu	-0.25(5000)	58	-1.7	0.4	-1.5	0.6	300	4.0
Zn	-1.75(200)	92	—	—	—	—	—	—
Mo	-3.75(2)	46	-3.4	0.4	-3.7	0.5	2	3.3
Sb	-2.08(100)	85	—	—	—	—	—	—
Sn	-2.75(20)	85	—	—	—	—	—	—
Ba	-2.08(100)	8	-0.8	0.5	-1.0	0.6	1000	4.2
Be	-4.08(1)	100	—	—	—	—	—	—
Co	-3.42(5)	23	-2.4	0.7	-2.7	0.9	20	8.0
Cr	-3.42(5)	8	-2.7	0.3	-2.8	0.4	15	2.3
La	—	0	-2.5	0.1	—	—	30	1.4
Mn	-3.08(10)	8	-2.2	0.2	-2.3	0.3	50	2.2
Nb ⁶	—	—	—	—	—	—	—	—
Ni	—	0	-2.9	0.4	—	—	15	2.4
Sr	-2.08(100)	8	-1.0	0.4	-1.1	0.5	700	3.5
V	—	0	-2.0	0.3	—	—	100	2.0
Y	-3.08(10)	100	—	—	—	—	—	—
Fe	—	0	0.7	0.3	—	—	5%	2.1
Mg	-1.75(200)	15	-1.1	0.3	-1.2	0.4	700	2.6
Ca	-1.42(500)	23	-0.9	0.2	-1.1	0.3	1000	1.9
Ti	—	0	-0.3	0.2	—	—	5000	1.6
16 unoxidized average-grade ore samples								
Au	—	0	-3.1	0.6	—	—	7.3	4.0
Ag	—	0	-2.5	0.6	—	—	30	3.9
Pb	—	0	-1.5	0.5	—	—	300	2.8
Bi	—	0	-1.8	0.6	—	—	150	4.4
Hg	-3.22(6)	⁴⁴	-4.1	0.5	-3.4	0.9	3.9	7.9
As	-0.30(5000)	⁴⁴	-1.3	0.8	-0.5	1.2	3200	16.3
Cu	—	0	0.1	0.6	—	—	1.5%	3.8
Zn	-1.75(200)	81	—	—	—	—	—	—
Mo	-3.58(3)	31	-3.2	0.2	-3.4	0.3	5	2.1
Sb	-2.08(100)	13	-0.7	0.5	-0.9	0.7	1500	5.2
Sn	-3.08(10)	25	-1.5	0.8	-2.1	1.2	100	15.8
Te	-1.08(1000)	81	—	—	—	—	—	—
Ba	—	0	-1.6	0.2	—	—	300	1.7
Be	-4.08(1)	100	—	—	—	—	—	—
Co	—	0	-3.0	0.3	—	—	10	2.1
Cr	—	0	-3.3	0.3	—	—	5	2.0
La	-2.58(30)	94	—	—	—	—	—	—
Mn	—	0	-3.1	0.3	—	—	7	2.0
Nb	-3.25(7)	88	—	—	—	—	—	—
Ni	—	0	-2.7	0.4	—	—	20	2.5
Sr	—	0	-1.8	0.4	—	—	150	2.3
V	—	0	-2.4	0.3	—	—	50	2.1
Y	3.08(10)	94	—	—	—	—	—	—
Fe	1.08(10)	³⁸	0.5	0.2	0.8	0.4	7%	2.6
Mg	-2.75(20)	56	-2.3	0.2	-2.8	0.5	15	3.3
Ca	—	0	-1.4	0.3	—	—	500	1.9
Ti	—	0	-1.2	0.3	—	—	700	2.0

TABLE 2.—Statistical data for unaltered dacite, unoxidized silicified dacite, and ore samples.—Continued

Element	Detection limit, log percent (ppm)	Percent samples outside detection limit	Logarithmic mean, log percent	Logarithmic standard deviation, log percent	Cohen's mean, log percent	Cohen's standard deviation, log percent	Geometric mean, ppm or percent (noted)	Geometric deviation
15 unoxidized high-grade ore samples								
Au	-----	0	-1.2	0.9	-----	-----	700	8.8
Ag	-----	0	-1.1	0.8	-----	-----	1000	6.5
Pb	-----	0	-1.6	-----	-----	-----	200	3.6
Bi	-----	0	-0.3	1.1	-----	-----	5000	11.2
Hg	-2.75(20)	7	-1.6	0.6	-1.7	0.7	200	4.9
As	-1.75(200)	20	0.7	0.5	0.1	1.3	1.5%	19.9
Cu	-----	0	0.8	1.0	-----	-----	7%	10.8
Zn	-2.08(100)	27	-0.8	0.4	-1.3	0.9	500	7.2
Mo	-3.75(2)	33	-2.8	0.4	-3.2	0.8	7	6.4
Sb	-----	0	0.1	1.1	-----	-----	1%	11.9
Sn	-3.25(7)	20	-0.6	0.8	-1.2	1.6	700	36.3
Te	-1.08(1000)	13	0.2	0.5	0.0	0.7	1%	4.7
Cd	-2.42(50)	27	-1.5	0.3	-1.8	0.6	150	3.8
Ba	-----	0	-2.4	0.7	-----	-----	50	5.6
Be	-4.08(1)	100	-----	-----	-----	-----	-----	-----
Co	-3.75(2)	20	-2.7	0.5	-2.9	0.7	10	5.3
Cr	-4.08(1)	7	-3.4	0.3	-3.5	0.4	3	2.3
La	-2.58(30)	93	-----	-----	-----	-----	-----	-----
Mn	-4.08(1)	20	-3.4	0.5	-3.5	0.6	3	3.9
Nb	s3.25(7)	93	-----	-----	-----	-----	-----	-----
Ni	-4.08(1)	13	-3.0	0.6	-3.2	0.7	7	5.3
Sr	-3.42(5)	20	-2.1	0.6	-2.4	0.9	30	7.8
V	-3.58(3)	13	-2.2	0.2	-2.4	0.6	50	3.6
Y	-3.08(10)	93	-----	-----	-----	-----	-----	-----
Fe	-----	0	-0.2	0.6	-----	-----	7000	4.1
Mg	-3.75(2)	7	-3.0	0.5	-3.1	0.5	10	3.3
Ca	-3.25(7)	20	-2.2	0.7	-2.5	0.9	30	8.4
Ti	-----	0	-1.9	0.8	-----	-----	150	5.9

¹More than one detection limit applies for some elements in some data sets. The detection limit used in calculations is shown.

²Ppm figure is near the midpoint of a range of concentrations equal to $\sqrt[3]{10}$. The log percent figure is the lower boundary for the same range. Applies to all elements except Au, Hg, and As in unaltered dacite, unoxidized silicified dacite, and unoxidized average-grade ore samples, where log percent and ppm figures represent the same value.

³Determined for 16 samples.

⁴Determined for 8 samples.

⁵Percentage of samples above upper detection limit. For other elements, percentage given is the number of samples below a lower detection limit.

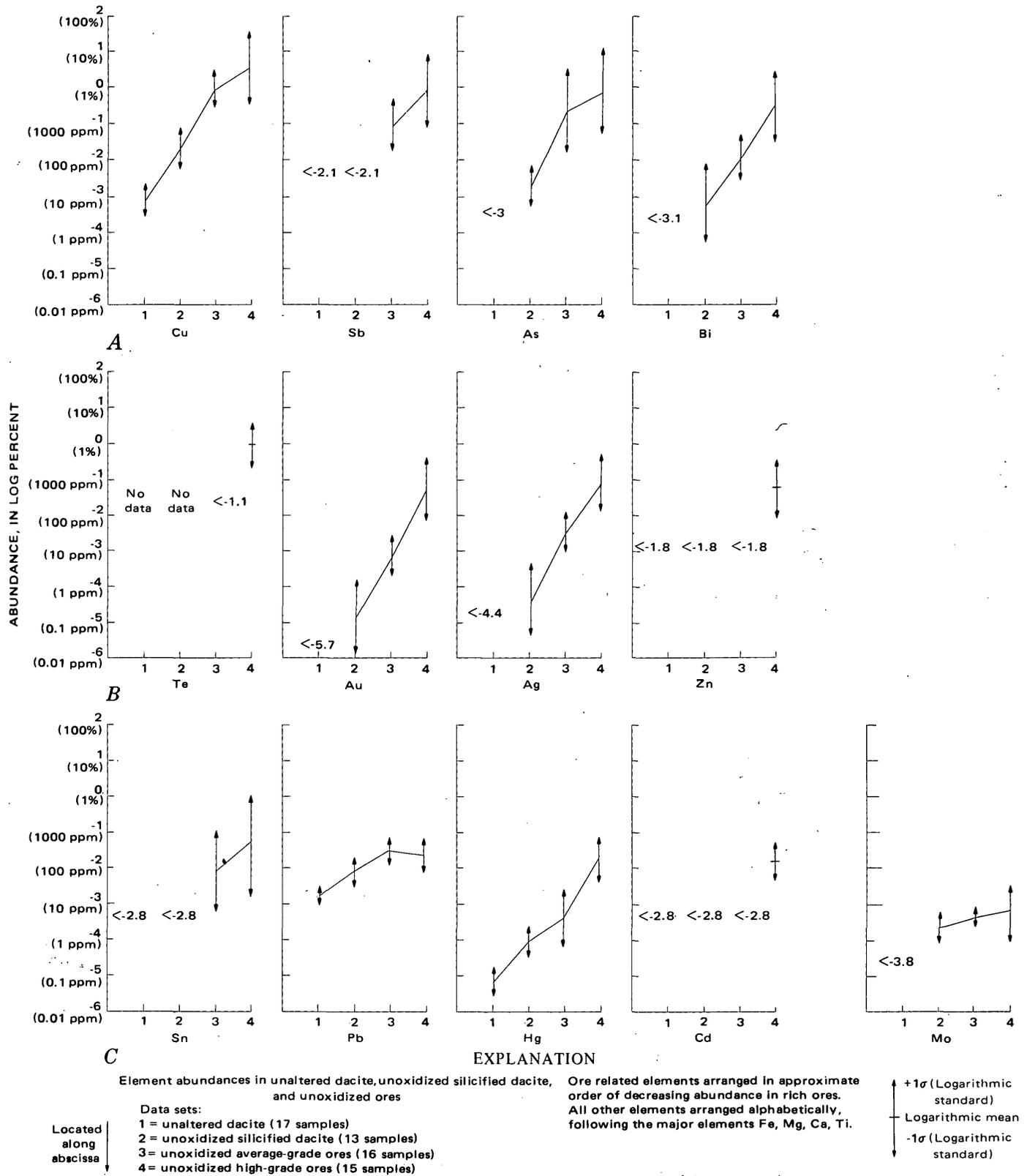
⁶No data.

relatively little pyrite, so these samples contain significantly smaller amounts of iron. Amounts of cobalt, chromium, nickel, and vanadium vary little or not at all through the groups of samples. Cobalt and nickel (Ramdohr, 1969, p. 779) probably are retained in pyrite along with iron. These two elements are not, however, significantly less abundant in the high-grade ores, as is true for iron; small amounts may have been introduced into the high-grade ores along with the abundant base and precious metals found in them. Cobalt and nickel data for the high-grade ores show significantly larger logarithmic standard deviations than do the data for average-grade ores; these facts suggest that more complex processes involving addition, as well as removal, influenced cobalt and nickel concentrations in the high-grade ores. It is not clear why chromium and vanadium are not more strongly depleted; we do not know which mineral phase or phases they reside in. Vanadium in the ores could reside in tetrahedrite-tennantite or farnatinitite; substantial amounts of vanadium occur in colusite (Cu₃(Sn, V, As)S₄), a mineral closely related to both the luzonite and tetrahedrite-tennantite mineral series (Levy, 1967, p. 129).

Magnesium, calcium, and manganese each show a pronounced and progressive decrease; the decreases indicate that depletion is directly related to intensity of

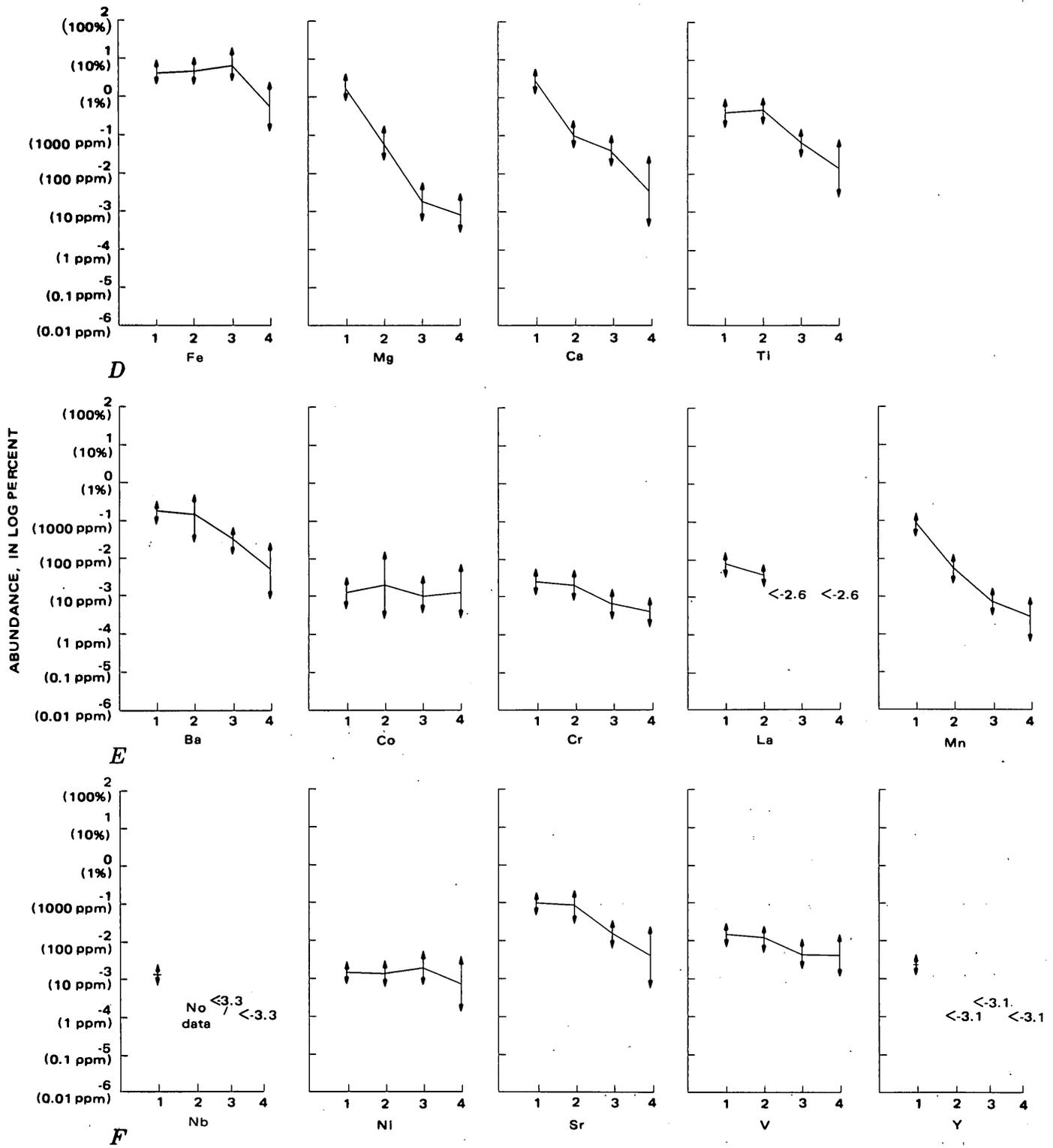
hydrothermal activity. The same is true of titanium, barium, and strontium, except that each of these shows no significant difference in abundance between unaltered and unoxidized silicified dacite samples. Barium and strontium data, however, show significantly larger logarithmic standard deviations in unoxidized silicified rocks than they do in unaltered rocks; these facts suggest that hydrothermal alteration produced a net increase in barium and strontium in some samples and a net loss in other samples. Thin sections of the unoxidized silicified dacite samples show that titanium is retained in leucosene (fine-grained anatase, TiO₂) or, in some samples, rutile (TiO₂), and barium and strontium are retained in barite (BaSO₄) or celestite (SrSO₄) or both. Barite and celestite form a continuous solid-solution series, but natural minerals are generally nearly pure BaSO₄ or SrSO₄ (Deer and others, 1962, p. 187-188, 197-198). The barite-celestite series minerals recognized in thin section are too fine grained to separate easily for a more exact composition determination. It is not surprising to find barite (or celestite) along with the abundant alunite (KAl₃(SO₄)₂(OH)₆) in the silicified rocks, since all these minerals are sulfates. Alunite abundance generally decreases with increasing amounts of ore minerals, and barite (celestite) probably decreases also.

Titanium, barium, and strontium could potentially



A, Cu, Sb, As, and Bi. B, Te, Au, Ag, and Zn. C, Sn, Pb, Hg, Cd, and Mo.

FIGURE 6.—Element abundances in unaltered dacite,



D, Fe, Mg, Ca, and Ti. E, Ba, Co, Cr, La, and Nb. F, Mn, Ni, Sr, V, and Y.

unoxidized silicified dacite, and unoxidized ores.

form negative geochemical anomalies in areas with gold metallization. These elements could also conceivably be depleted, however, by particularly strong or long-enduring hydrothermal activity without metallization. Use of negative anomalies, furthermore, requires particularly careful chemical analysis and involves greater difficulties in interpretation than use of positive anomalies; therefore these elements will not be considered further.

Lanthanum, niobium, and yttrium probably are depleted relative to amounts in fresh dacite, but little else can be said with the data available.

DISPERSION PATTERNS OF ORE-RELATED ELEMENTS IN THE OXIDIZED ZONE

This section discusses the relations between gold, lead, silver, bismuth, mercury, arsenic, copper, molybdenum, and zinc in oxidized rocks of the Combination and January mines. Though gold, lead, silver, bismuth, and mercury form primary aureoles around the ore bodies, they are restricted to silicified rocks. These aureoles persist through supergene oxidation. Arsenic, copper, molybdenum, and zinc have all been rather strongly leached during supergene oxidation, but coherent secondary halos did not form.¹¹

The 278 samples of oxidized hydrothermally altered dacite that provide the data for this part of the report were collected every 5 feet about 4 feet above the floor of the large central cut, the smaller northwesternmost cut, and the northwestern part of the cut east of the Combination shaft (see pl. 2). Much of the last cut is occupied by caved material over stopes; samples here were taken about 4 feet above the top of the cave-in debris accumulated against the upper walls. The present walls are partly, perhaps largely, scarps left by blocks that broke off and slid or fell into the large caved area. Except for the caved area, the walls at the time of sampling and mapping were freshly excavated and very steep, representing elevation changes between 15 and 50 feet along any given profile across the cut wall.

Open workings, some forming precipitous holes, disrupt the sampling scheme at most of the 14 locations where they intersect the cuts. Six of these are located along the west wall of the largest cut between localities 2 and 7 (pl. 2). These all lie within silicified rocks, and field examination indicates that they are probably old stopes. The seventh location (loc. 20), at the southeast end of the large caved area, in argillized rocks, is probably an access drift. Three more openings are located on the wall of the largest cut, between localities 6 and 7, and connect with the large opening shown at 7. The last

four appear in the vicinity of locality 8 and probably were originally interconnected. All the workings represented by the latter two groups of openings are tunnels and possibly stopes that intersect the nearly vertical cut wall at various elevations; the several near locality 8 almost overlap when projected onto a horizontal plane. For simplicity, therefore, these workings are not included on the plates. To place the resulting problem of sampling bias in perspective, 12 of the existing samples (samples 88, 89, 90, 91, 92, 161, 162, 185, 186, 187, 194, 195 on pl. 2; about 9 percent of the silicified rock samples) came from the walls or floors of stopes and probably contain less gold and other gold-related elements than the mined-out rock. Furthermore, several additional samples would have been taken in the vicinity of locality 8, had it not been previously disrupted by mining activity.

ELEMENT DISTRIBUTION MAPS

The analytical and statistical data used to make the element distribution maps (pls. 3 and 4) and accompanying histograms are given in tables 3 and 4. The cuts generally parallel the vein system, but they expose one section approximately across strike immediately northwest of the Combination shaft (see A-A', pls. 2-4). A geochemical profile for this section is shown for each element along with the geochemical map to show the degree of contrast between oxidized metallized silicified and nonmetallized argillized rocks. This contrast is also termed "anomaly height-to-background ratio," or "anomaly contrast." The histograms accompanying each geochemical map show the relative amounts of each element in silicified versus argillized rocks and also the relative numbers of samples included in each range of values represented by a different map symbol.

Tellurium and antimony maps are not included because replicate analyses indicated that sample preparation and extraction problems affected the atomic absorption and colorimetric analyses for these elements. Replicate determinations resulted in values from 10 to as much as 100 times higher than the first determinations. Possibly, tellurium and antimony in these rocks are very finely divided and were not quantitatively liberated from the quartz matrix with the original grinding and extraction procedure. Unfortunately, the original splits for many samples were depleted before this problem was satisfactorily solved, so the limited newer data are not worth examining in detail. The data available suggest, however, that both tellurium and antimony are enriched in metallized silicified rocks relative to surrounding argillized rocks.

Maps were not prepared for tin and cadmium, the two remaining potential indicator elements (ignoring selenium), because only 17 of the 278 samples from the

¹¹Our use of the terms "primary," "secondary," "aureole," and "halo" is the same as that of Hawkes and Webb (1962). Since the Goldfield deposits are epigenetic (and hypogenetic), our usage is also concordant with revised definitions of the terms "primary" and "secondary" proposed by James (1967).

cuts had 3 ppm or more of tin, and none of the samples had as much as 50 ppm of cadmium.

GOLD

All but three high gold values (greater than or equal to 3 ppm) and most intermediate gold values (1–2.9 ppm) are in silicified rocks (pl. 3). The three high values in argillized rocks are all from fault or shear zones adjacent to silicified zones (see locs. 5, 6, and 18, pl. 3). Of the six intermediate values in argillized rocks, two are from fault zones between argillized and silicified rocks (loc. 9 and fault at loc. 6), and two more are within 5 feet of silicified zones but are not associated with conspicuous structures (locs. 4 and 19). The remaining two intermediate values, at locality 3, are at least 20–30 feet southwest of the nearest silicified rock contact exposed in the wall of the cut or projected along the floor of the cut toward locality 4 and are not associated with structures. All remaining samples from argillized rocks have less than 1 ppm gold; many have less than 0.1 ppm. (The detection threshold for gold for samples from the cuts is 0.1 ppm, whereas it is 0.02 ppm for the unaltered dacite samples and unoxidized silicified rocks discussed in the previous section.)

The histograms reflect substantially different amounts of gold in oxidized silicified versus oxidized argillized rocks. The geometric mean for silicified rocks, 1.3 ppm, is more than 10 times that determined for argillized rocks, 0.1 ppm. The frequency distribution for silicified rocks is relatively symmetrical, with a rather broad peak between -4.00 and -3.50 log percent (between approximately 1 and 3 ppm). If ore samples had been available from the 12 locations at which old stopes intersect the walls of the cuts, the upper tail of the histogram, representing values of 10 ppm or more, would presumably be somewhat larger. A large number of values appear at the left end of each gold histogram just above the detection threshold. Most of the readings that contribute to these large frequencies in the class interval immediately above the detection threshold are readings of "0.1 ppm." In fact, because 44 of the 278 samples were read as 0.1 ppm whereas only 17 samples were read between 0.1 and 0.2 ppm, analytical discrimination was poor for samples near the detection threshold. Consequently, both readings of "0.1 ppm" and "less than 0.1 ppm" are given the same symbol on plate 3.

Although silicification is by far the most important feature associated with relatively high gold values, the silicified zones do not show uniformly high values. The west edge of the vein system, exposed between localities 7 and 10 and on the wall to the west and north of the January shaft, shows the lowest values. The small silicified bodies at localities 14 and 15 also show low values. Along the wall between localities 2 and 5, even

though the overall gold tenor is relatively high, many adjacent samples have substantially different amounts of gold. Southeastward along the vein system, individual exposures are unpredictable. Relatively high values appear in the vicinity of locality 12, low values at locality 16, and high values again east of locality 19. Localities 18 and 20 are each represented by only one sample; more information is needed to categorize these outcrops. The geochemical profile, which includes locality 12, shows nearly the maximum anomaly contrast that is expected between metallized silicified rocks and argillized rocks, unless the sampling included ore-grade material. The geochemical profile also shows a sharp break within the large silicified zone at locality 12; the sharp break is produced by an isolated very low reading. Variations in values for the six samples between localities 6 and 7 provide another example of irregularities that apparently must be expected; such irregularities are a potential source of error when determining the average gold content of the silicified zones.

Sampling error related to removal of material from an outcrop or face probably contributes to the abrupt variations in gold values.¹² Before the oxidized-rock samples were processed for analysis, we removed and saved a 0.5- to 1-kg hand specimen from each sample. These hand specimens may be considered replicate samples from each of the localities shown on plates 2–4. We obtained gold analyses for the replicate samples from 88 of the 129 oxidized silicified rock localities. For 65 of these 88 localities, both the original sample and replicate sample showed 1 ppm gold or more. Because analytical error is substantially lower above 1 ppm than below 1 ppm, we compared original and replicate sample analyses only for the 65 samples. Using Garret's (1969) method for comparing combined sampling and analytical error with overall data variability by means of an F-test, σ_{SA}^2 (combined sampling and analytical variance) is 0.058, σ_D^2 (data variance) is 0.11, and the value of F calculated is 1.90. Tables of the F distribution give 3.92 for degrees of freedom 1,128 at the 95-percent-confidence level (1.34 at the 75-percent-confidence level). Since our calculated F does not exceed 3.92, we must conclude that chances are greater than 1 in 20 (but less than 1 in 4) that combined sampling and analytical variance rather than real variation between sample localities is responsible for the variability seen in samples containing more than 1 ppm gold.

Sampling error related to removal of an analytical

¹²The terms "sampling variance" and "sampling error" refer to variation introduced into the data by samples or analytical portions of samples that are not truly representative of the localities from which they were taken. Geologic processes must account for the abrupt variations in amounts of an element within an outcrop or a hand specimen that produce sampling error. The terms "analytical variance" and "analytical error," on the other hand, refer to variation introduced into the data by imprecision in the laboratory analytical procedure.

TABLE 3.—Analytical data for oxidized silicified and argillized rock samples from the Combination-January cuts

Sample	Au		Ag		Pb		Bi		Hg		As		Cu		Zn		Mo		Ba		Be		Co	
	ppm	log %	ppm	log %	ppm	log %	ppm	log %	ppm	log %	ppm	log %	ppm	log %	ppm	log %	ppm	log %	ppm	log %	ppm	log %	ppm	log %
Silicified rocks																								
1	1.8	-3.74	10	-3.00	150	-1.82	N(5)	-----	0.50	-4.30	60	-2.22	20	-2.70	L(25)	-----	N(3)	-----	700	-1.15	N(0.3)	-----	N(3)	-----
2	0.88	-4.06	1.5	-3.82	100	-2.00	N(5)	-----	1.00	-4.00	40	-2.40	7	-3.15	L(25)	-----	N(3)	-----	700	-1.15	N(0.3)	-----	N(3)	-----
3	1.5	-3.82	2	-3.70	500	-1.30	N(5)	-----	10	-5.00	L(10)	-----	20	-2.70	L(25)	-----	N(3)	-----	700	-1.15	N(0.3)	-----	N(3)	-----
4	1.0	-4.00	1	-4.00	70	-2.15	N(5)	-----	10	-5.00	120	-1.92	15	-2.82	L(25)	-----	N(3)	-----	700	-1.15	N(0.3)	-----	N(3)	-----
5	.69	-4.16	2	-3.70	100	-2.00	N(5)	-----	10	-5.00	10	-3.00	7	-3.15	L(25)	-----	N(3)	-----	700	-1.15	N(0.3)	-----	N(3)	-----
6	2.0	-3.70	3	-3.52	150	-1.82	10	-3.00	10	-5.00	L(10)	-----	10	-3.00	L(25)	-----	N(3)	-----	700	-1.15	N(0.3)	-----	N(3)	-----
7	4.5	-3.35	20	-2.70	500	-1.30	15	-2.82	.50	-4.30	10	-3.00	100	-2.00	L(25)	-----	N(3)	-----	700	-1.15	N(0.3)	-----	N(3)	-----
8	3.1	-3.51	3	-3.52	200	-1.70	10	-3.00	.20	-4.70	10	-3.00	15	-2.82	L(25)	-----	N(3)	-----	700	-1.15	N(0.3)	-----	N(3)	-----
9	3.4	-3.47	3	-3.52	200	-1.70	10	-3.00	.20	-4.70	10	-3.00	30	-2.52	L(25)	-----	N(3)	-----	700	-1.15	N(0.3)	-----	N(3)	-----
10	1.9	-3.73	3	-3.52	200	-1.70	N(5)	-----	.20	-4.70	120	-1.92	50	-2.30	L(25)	-----	N(3)	-----	700	-1.15	N(0.3)	-----	N(3)	-----
11	2.8	-3.55	3	-3.52	70	-2.15	30	-2.52	.50	-4.30	160	-1.80	200	-1.70	L(25)	-----	N(3)	-----	300	-1.52	N(0.3)	-----	30	-2.52
30	.80	-4.10	1.5	-3.82	500	-1.30	10	-3.00	.11	-4.96	10	-3.00	30	-2.52	L(25)	-----	10	-3.00	2,000	-1.70	3	-4.52	5	-3.30
32	1.5	-3.84	3	-3.52	150	-1.82	5	-3.30	.08	-5.10	60	-2.22	30	-2.52	L(25)	-----	7	-3.15	200	-1.70	3	-4.52	5	-3.30
34	1.5	-3.82	0.3	-4.52	300	-1.52	N(5)	-----	.11	-4.96	10	-3.00	10	-3.00	L(25)	-----	3	-3.52	700	-1.15	5	-4.30	5	-3.30
35	L(0.1)	-----	7	-4.15	300	-1.52	N(5)	-----	.06	-5.22	10	-3.00	20	-2.70	25	-2.60	10	-3.00	150	-1.82	3	-4.52	5	-3.30
36	2.9	-3.54	2	-3.70	500	-1.30	N(5)	-----	.08	-5.10	L(10)	-----	30	-2.52	L(25)	-----	3	-3.52	200	-1.70	3	-4.52	5	-3.30
37	7.1	-3.15	1.5	-3.82	700	-1.15	N(5)	-----	.15	-4.82	L(10)	-----	15	-2.82	L(25)	-----	3	-3.52	700	-1.15	3	-4.52	5	-3.30
38	6.4	-3.19	2	-3.70	300	-1.52	N(5)	-----	.15	-4.82	10	-3.00	5	-3.30	L(25)	-----	N(3)	-----	1,000	-1.00	3	-4.52	5	-3.30
39	4.3	-3.37	2	-3.70	700	-1.15	N(5)	-----	.24	-4.62	10	-3.00	7	-3.15	L(25)	-----	3	-3.52	1,000	-1.00	3	-4.52	5	-3.30
45	2.9	-3.54	5	-3.30	50	-2.30	50	-2.30	.20	-4.70	10	-3.00	30	-2.52	L(25)	-----	N(3)	-----	200	-1.70	5	-4.30	7	-3.15
63	.10	-5.00	5	-3.30	30	-2.52	N(5)	-----	.13	-4.89	60	-2.22	20	-2.70	25	-2.60	15	-2.82	700	-1.15	3	-4.52	5	-3.30
64	.10	-5.00	N(0.1)	-----	N(2)	-----	N(5)	-----	10	-5.00	80	-2.10	15	-2.82	30	-2.52	5	-3.30	1,000	-1.00	N(0.3)	-----	N(3)	-----
65	1.4	-3.85	N(0.1)	-----	200	-1.70	N(5)	-----	.08	-5.10	40	-2.40	15	-2.82	L(25)	-----	5	-3.30	1,000	-1.00	N(0.3)	-----	N(3)	-----
66	.90	-4.05	N(0.1)	-----	100	-2.00	N(5)	-----	.06	-5.22	100	-2.00	10	-3.00	L(25)	-----	N(3)	-----	700	-1.15	N(0.3)	-----	N(3)	-----
67	2.8	-3.56	N(0.1)	-----	150	-1.82	N(5)	-----	.11	-4.96	10	-3.00	20	-2.70	L(25)	-----	N(3)	-----	3,000	-1.52	N(0.3)	-----	N(3)	-----
68	2.1	-3.68	N(0.1)	-----	700	-1.15	N(5)	-----	.06	-5.22	100	-2.00	5	-3.30	L(25)	-----	5	-3.30	500	-1.30	N(0.3)	-----	N(3)	-----
69	.10	-5.00	N(0.1)	-----	100	-2.00	N(5)	-----	.06	-5.22	80	-2.10	7	-3.15	L(25)	-----	N(3)	-----	500	-1.30	N(0.3)	-----	N(3)	-----
74	.18	-4.74	N(0.1)	-----	30	-2.52	N(5)	-----	.06	-5.22	10	-3.00	100	-2.00	N(3)	-----	7	-3.15	700	-1.15	N(0.3)	-----	N(3)	-----
75	1.8	-3.74	N(0.1)	-----	200	-1.70	N(5)	-----	.15	-4.82	140	-1.85	70	-2.15	L(25)	-----	7	-3.15	700	-1.15	N(0.3)	-----	N(3)	-----
77	.30	-4.52	L(1)	-----	150	-1.82	N(5)	-----	.15	-4.82	20	-2.70	10	-3.00	50	-2.30	5	-3.30	500	-1.30	N(0.3)	-----	N(3)	-----
78	2.4	-3.62	L(1)	-----	500	-1.30	N(5)	-----	.17	-4.77	160	-1.80	15	-2.82	40	-2.40	5	-3.30	500	-1.30	N(0.3)	-----	N(3)	-----
79	.36	-4.44	L(1)	-----	150	-1.82	N(5)	-----	.11	-4.96	140	-1.85	20	-2.70	140	-1.85	5	-3.30	700	-1.15	N(0.3)	-----	N(3)	-----
80	1.5	-3.82	L(1)	-----	70	-2.15	N(5)	-----	.15	-4.82	200	-1.70	70	-2.15	L(25)	-----	10	-3.00	500	-1.30	N(0.3)	-----	N(3)	-----
81	2.5	-3.61	5	-3.30	200	-1.70	30	-2.52	.11	-4.96	10	-3.00	10	-3.00	L(25)	-----	N(3)	-----	700	-1.15	N(0.3)	-----	N(3)	-----
82	2.9	-3.54	3	-3.52	200	-1.70	30	-2.52	.19	-4.72	10	-3.00	10	-3.00	L(25)	-----	N(3)	-----	700	-1.15	N(0.3)	-----	N(3)	-----
83	1.2	-3.92	3	-3.52	150	-1.82	N(5)	-----	.13	-4.89	10	-3.00	10	-3.00	L(25)	-----	N(3)	-----	500	-1.30	N(0.3)	-----	N(3)	-----
84	1.9	-3.72	1	-4.00	200	-1.70	N(5)	-----	.11	-4.96	20	-2.70	15	-2.82	L(25)	-----	N(3)	-----	1,000	-1.00	N(0.3)	-----	N(3)	-----
85	.16	-4.80	1	-4.00	150	-1.82	N(5)	-----	.06	-5.22	20	-2.70	10	-3.00	L(25)	-----	N(3)	-----	200	-1.70	N(0.3)	-----	N(3)	-----
86	1.7	-3.77	5	-3.30	150	-1.82	30	-2.52	.11	-4.96	20	-2.70	15	-2.82	L(25)	-----	N(3)	-----	700	-1.15	N(0.3)	-----	N(3)	-----
87	1.4	-3.85	3	-3.52	300	-1.52	30	-2.52	.04	-5.40	10	-3.00	15	-2.82	L(25)	-----	N(3)	-----	700	-1.15	N(0.3)	-----	N(3)	-----
88	.90	-4.05	3	-3.52	200	-1.70	30	-2.52	.04	-5.40	20	-2.70	15	-2.82	40	-2.40	N(3)	-----	700	-1.15	5	-4.30	5	-3.30
89	.55	-4.26	3	-3.52	100	-2.00	N(5)	-----	.06	-5.22	10	-3.00	5	-3.30	L(25)	-----	N(3)	-----	300	-1.52	5	-4.30	5	-3.30
90	9.7	-3.02	1	-4.00	300	-1.52	N(5)	-----	.06	-5.22	10	-3.00	20	-2.70	L(25)	-----	N(3)	-----	500	-1.30	5	-4.30	5	-3.30
91	9.4	-3.03	1.5	-3.82	150	-1.82	N(5)	-----	.11	-4.96	L(10)	-----	7	-3.15	L(25)	-----	N(3)	-----	2,000	-1.70	N(0.3)	-----	N(3)	-----
92	.10	-5.00	.5	-4.30	150	-1.82	N(5)	-----	.06	-5.22	60	-2.22	10	-3.00	L(25)	-----	10	-3.00	500	-1.30	.7	-4.15	5	-3.30
101	2.3	-3.65	1	-4.00	300	-1.52	N(5)	-----	.10	-5.00	10	-3.00	10	-3.00	30	-2.52	3	-3.52	1,500	-1.82	1.5	-3.82	5	-3.30
116	.16	-4.80	L(1)	-----	7	-3.15	N(5)	-----	.10	-5.00	100	-2.00	20	-2.70	50	-2.30	5	-3.30	200	-1.70	N(0.3)	-----	N(3)	-----
117	.10	-5.00	L(1)	-----	7	-3.15	N(5)	-----	.10	-5.00	20	-2.70	20	-2.70	L(25)	-----	N(3)	-----	1,000	-1.00	N(0.3)	-----	N(3)	-----
118	.10	-5.00	L(1)	-----	15	-2.82	N(5)	-----	.10	-5.00	40	-2.40	5	-3.30	L(25)	-----	10	-3.00	700	-1.15	N(0.3)	-----	N(3)	-----
119	.29	-4.54	N(0.1)	-----	70	-2.15	N(5)	-----	.08	-5.10	10	-3.00	5	-3.30	L(25)	-----	N(3)	-----	700	-1.15	N(0.3)	-----	N(3)	-----
120	.10	-5.00	2	-3.70	50	-2.30	N(5)	-----	.10	-5.00	L(10)	-----	5	-3.30	L(25)	-----	5	-3.30	1,000	-1.00	N(0.3)	-----	N(3)	-----
121	.17	-4.77	N(0.1)	-----	70	-2.15	N(5)	-----	.10	-5.00	80	-2.10	30	-2.52	65	-2.19	7	-3.15	300	-1.52	N(0.3)	-----	N(3)	-----
129	.20	-4.70	L(1)	-----	50	-2.30	N(5)	-----	.06	-5.22	200	-1.70	30	-2.52	50	-2.30	10	-3.00	2,000	-1.70	N(0.3)	-----	N(3)	-----
130	2.4	-3.63	L(1)	-----	300	-1.52	N(5)	-----	.19	-4.72	160	-1.80	50	-2.30	90	-2.05	15	-2.82	700	-1.15	N(0.3)	-----	N(3)	-----
142	1.6	-3.80	N(0.1)	-----	300	-1.52	N(5)	-----	.52	-4.28	10	-3.00	3	-3.52	50	-2.30	N(3)	-----	700	-1.15	N(0.3)	-----	N(3)	-----
161	1.6	-3.80	L(1)	-----	700	-1.15	N(5)	-----	.11	-4.96	120	-1.92	10	-3.00	60	-2.22	N(3)	-----	700	-1.15	N(0.3)	-----	N(3)	-----
162	.20	-4.70	N(0.1)	-----	70	-2.15	N(5)	-----	.35	-4.46	10	-3.00	3	-3.52	160	-1.80	N(3)	-----	300	-1.52	N(0.3)	-----	N(3)	-----
163	15	-2.81	1	-4.00	700	-1.15	30	-2.52	.35	-4.46	100	-2.00	15	-2.82	25	-2.60	5	-3.30	700	-1.15	N(0.3)	-----	N(3)	-----
166	19	-2.72	L(1)	-----	100	-2.00	N(5)	-----	.22	-4.66	20	-2.70	3	-3.52	30	-2.52	N(3)	-----	500	-1.30	N(0.3)	-----	N(3)	-----
167	8.0	-3.10	L(1)	-----	500	-1.30	N(

Sample	Cr		La		Mn		Nb		Ni		Sr		V		Y		Fe		Mg		Ca		Ti	
	ppm	log %	ppm	log %	ppm	log %	ppm	log %	ppm	log %	ppm	log %	ppm	log %	ppm	log %	ppm	log %	ppm	log %	ppm	log %	ppm	log %
Silicified rocks — Continued																								
1	10	-3.00	N(30)	----	150	-1.82	N(3)	----	N(2)	----	700	-1.15	70	-2.15	N(3)	----	15,000	0.18	100	-2.00	700	-1.15	3,000	-0.52
2	10	-3.00	N(30)	----	15	-2.82	N(3)	----	N(2)	----	500	-1.30	70	-2.15	N(3)	----	5,000	-.30	100	-2.00	700	-1.15	3,000	-.52
3	10	-3.00	N(30)	----	15	-2.82	N(3)	----	N(2)	----	700	-1.15	70	-2.15	N(3)	----	15,000	-.18	100	-2.00	700	-1.15	3,000	-.52
4	10	-3.00	N(30)	----	30	-2.52	N(3)	----	N(2)	----	500	-1.30	100	-2.00	N(3)	----	5,000	-.30	70	-2.15	700	-1.15	3,000	-.52
5	15	-2.82	N(30)	----	7	-3.15	N(3)	----	N(2)	----	300	-1.52	100	-2.00	N(3)	----	2,000	-.70	100	-2.00	1,000	-1.00	3,000	-.52
6	10	-3.00	N(30)	----	20	-2.70	N(3)	----	N(2)	----	300	-1.52	70	-2.15	N(3)	----	7,000	-.15	100	-2.00	1,000	-1.00	3,000	-.52
7	10	-3.00	N(30)	----	20	-2.70	N(3)	----	N(2)	----	500	-1.30	70	-2.15	N(3)	----	20,000	-.30	100	-2.00	700	-1.15	3,000	-.52
8	10	-3.00	N(30)	----	20	-2.70	N(3)	----	N(2)	----	500	-1.30	70	-2.15	N(3)	----	15,000	-.18	70	-2.15	700	-1.15	3,000	-.52
9	10	-3.00	N(30)	----	30	-2.52	N(3)	----	N(2)	----	500	-1.30	70	-2.15	N(3)	----	20,000	-.30	100	-2.00	3,000	-.52	3,000	-.52
10	10	-3.00	N(30)	----	70	-2.15	N(3)	----	N(2)	----	500	-1.30	50	-2.30	N(3)	----	20,000	-.30	70	-2.15	500	-1.30	1,500	-.82
11	10	-3.00	N(30)	----	300	-1.52	N(3)	----	N(2)	----	700	-1.15	200	-1.70	N(3)	----	G(100,000)	----	700	-1.15	3,000	-.52	700	-1.15
30	20	-2.70	30	-2.52	50	-2.30	N(3)	----	2	-3.70	500	-1.30	100	-2.00	5	-3.30	70,000	-.85	100	-2.00	500	-1.30	2,000	-.70
32	15	-2.82	N(30)	----	50	-2.30	N(3)	----	2	-3.70	500	-1.30	70	-2.15	5	-3.30	50,000	-.70	150	-1.82	300	-1.52	2,000	-.70
34	30	-2.52	70	-2.15	70	-2.15	N(3)	----	3	-3.52	1,500	-.82	70	-2.15	7	-3.15	70,000	-.85	2,000	-.70	1,000	-1.00	2,000	-.70
35	20	-2.70	70	-2.15	100	-2.00	N(3)	----	2	-3.70	1,500	-.82	150	-1.82	7	-3.15	100,000	1.00	200	-1.70	500	-1.30	3,000	-.52
36	20	-2.70	N(30)	----	50	-2.30	N(3)	----	2	-3.70	500	-1.30	70	-2.15	5	-3.30	50,000	-.70	150	-1.82	500	-1.30	2,000	-.70
37	20	-2.70	50	-2.30	20	-2.70	N(3)	----	2	-3.70	500	-1.30	70	-2.15	5	-3.30	30,000	-.48	150	-1.82	1,500	-.82	2,000	-.70
38	15	-2.82	50	-2.30	15	-2.82	N(3)	----	2	-3.70	1,500	-.82	70	-2.15	5	-3.30	10,000	-.00	150	-1.82	1,000	-1.00	2,000	-.70
39	15	-2.82	30	-2.52	20	-2.70	N(3)	----	2	-3.70	2,000	-.70	70	-2.15	5	-3.30	30,000	-.48	100	-2.00	1,000	-1.00	1,500	-.82
45	10	-3.00	70	-2.15	30	-2.52	10	-3.00	2	-3.70	300	-1.52	30	-2.52	7	-3.15	20,000	-.30	100	-2.00	300	-1.52	5,000	-.30
63	10	-3.00	50	-2.30	300	-1.52	N(3)	----	3	-3.52	1,000	-1.00	70	-2.15	5	-3.30	G(100,000)	----	700	-1.15	500	-1.30	2,000	-.70
64	20	-2.70	N(30)	----	300	-1.52	N(3)	----	N(2)	----	700	-1.15	70	-2.15	N(3)	----	30,000	-.48	1,000	-1.00	700	-1.15	3,000	-.52
65	20	-2.70	70	-2.15	30	-2.52	N(3)	----	N(2)	----	1,000	-1.00	100	-2.00	.20	-2.70	50,000	-.70	1,500	-.82	1,000	-1.00	3,000	-.52
66	20	-2.70	70	-2.15	10	-3.00	N(3)	----	N(2)	----	200	-1.70	70	-2.15	N(3)	----	30,000	-.48	N(1)	----	500	-1.30	2,000	-.70
67	20	-2.70	70	-2.15	30	-2.52	N(3)	----	N(2)	----	300	-1.52	70	-2.15	20	-2.70	15,000	-.18	1,500	-.82	1,500	-.82	3,000	-.52
68	15	-2.82	N(30)	----	10	-3.00	N(3)	----	N(2)	----	700	-1.15	70	-2.15	N(3)	----	50,000	-.70	N(1)	----	700	-1.15	1,500	-.82
69	20	-2.70	70	-2.15	10	-3.00	N(3)	----	N(2)	----	1,000	-1.00	70	-2.15	N(3)	----	20,000	-.30	300	-1.52	1,000	-1.00	2,000	-.70
74	15	-2.82	70	-2.15	7	-3.15	N(3)	----	N(2)	----	500	-1.30	70	-2.15	N(3)	----	10,000	-.00	N(1)	----	500	-1.30	2,000	-.70
75	15	-2.82	70	-2.15	30	-2.52	N(3)	----	N(2)	----	700	-1.15	70	-2.15	N(3)	----	70,000	-.85	N(1)	----	500	-1.30	2,000	-.70
77	15	-2.82	N(30)	----	7	-3.15	N(3)	----	N(2)	----	700	-1.15	70	-2.15	N(3)	----	30,000	-.48	N(1)	----	700	-1.15	3,000	-.52
78	10	-3.00	N(30)	----	7	-3.15	N(3)	----	N(2)	----	1,000	-1.00	70	-2.15	N(3)	----	30,000	-.48	N(1)	----	700	-1.15	1,500	-.82
79	15	-2.82	N(30)	----	7	-3.15	N(3)	----	N(2)	----	500	-1.30	70	-2.15	N(3)	----	30,000	-.48	N(1)	----	500	-1.30	2,000	-.70
80	10	-3.00	N(30)	----	15	-2.82	N(3)	----	N(2)	----	700	-1.15	70	-2.15	N(3)	----	50,000	-.70	N(1)	----	300	-1.52	1,500	-.82
81	15	-2.82	N(30)	----	70	-2.15	N(3)	----	N(2)	----	500	-1.30	30	-2.52	N(3)	----	3,000	-.52	70	-2.15	1,000	-1.00	3,000	-.52
82	15	-2.82	N(30)	----	10	-3.00	N(3)	----	N(2)	----	500	-1.30	30	-2.52	N(3)	----	5,000	-.70	100	-2.00	700	-1.15	3,000	-.52
83	20	-2.70	N(30)	----	7	-3.15	N(3)	----	N(2)	----	300	-1.52	50	-2.30	N(3)	----	3,000	-.52	70	-2.15	1,000	-1.00	1,500	-.82
84	20	-2.70	N(30)	----	7	-3.15	N(3)	----	N(2)	----	700	-1.15	70	-2.15	N(3)	----	50,000	-.70	70	-2.15	1,000	-1.00	2,000	-.70
85	20	-2.70	50	-2.30	10	-3.00	N(3)	----	N(2)	----	700	-1.15	70	-2.15	N(3)	----	7,000	-.15	100	-2.00	700	-1.15	2,000	-.70
86	20	-2.70	N(30)	----	7	-3.15	N(3)	----	N(2)	----	500	-1.30	70	-2.15	N(3)	----	50,000	-.70	100	-2.00	1,000	-1.00	2,000	-.70
87	20	-2.70	N(30)	----	7	-3.15	N(3)	----	N(2)	----	500	-1.30	70	-2.15	N(3)	----	1,500	-.82	100	-2.00	700	-1.15	2,000	-.70
88	10	-3.00	30	-2.52	15	-2.82	N(3)	----	N(2)	----	500	-1.30	70	-2.15	3	-3.52	5,000	-.30	150	-1.82	1,000	-1.00	3,000	-.52
89	3	-3.52	N(30)	----	3	-3.52	7	-3.15	N(2)	----	100	-2.00	15	-2.82	3	-3.52	2,000	-.70	70	-2.15	100	-2.00	5,000	-.30
90	15	-2.82	50	-2.30	7	-3.15	N(3)	----	N(2)	----	1,000	-1.00	70	-2.15	3	-3.52	1,000	-.70	70	-2.15	1,500	-.82	3,000	-.52
91	15	-2.82	30	-2.52	10	-3.00	N(3)	----	N(2)	----	150	-1.82	20	-2.70	3	-3.52	2,000	-.70	70	-2.15	700	-1.15	2,000	-.70
92	10	-3.00	50	-2.30	100	-2.00	N(3)	----	3	-3.52	300	-1.52	100	-2.00	20	-2.70	70,000	-.85	500	-1.30	700	-1.15	5,000	-.30
101	15	-2.82	50	-2.30	10	-3.00	N(3)	----	3	-3.52	150	-1.82	50	-2.30	10	-3.00	7,000	-.15	100	-2.00	300	-1.52	2,000	-.70
116	30	-2.52	100	-2.00	15	-2.82	20	-2.70	N(2)	----	500	-1.30	50	-2.30	N(3)	----	10,000	-.00	30	-2.52	200	-1.70	3,000	-.52
117	N(2)	----	N(30)	----	10	-3.00	20	-2.70	N(2)	----	20	-2.70	30	-2.52	N(3)	----	5,000	-.30	20	-2.70	200	-1.70	3,000	-.52
118	3	-3.52	N(30)	----	10	-3.00	20	-2.70	N(2)	----	100	-2.00	30	-2.52	N(3)	----	15,000	-.18	30	-2.52	70	-2.15	3,000	-.52
119	20	-2.70	70	-2.15	10	-3.00	10	-3.00	N(2)	----	700	-1.15	50	-2.30	N(3)	----	5,000	-.30	70	-2.15	500	-1.30	2,000	-.70
120	10	-3.00	150	-1.82	10	-3.00	20	-2.70	N(2)	----	700	-1.15	50	-2.30	N(3)	----	10,000	-.00	70	-2.15	300	-1.52	3,000	-.52
121	30	-2.52	70	-2.15	10	-3.00	N(3)	----	N(2)	----	700	-1.15	50	-2.30	N(3)	----	30,000	-.48	50	-2.30	500	-1.30	2,000	-.70
129	N(2)	----	100	-2.00	2,000	-0.70	15	-2.82	N(2)	----	200	-1.70	30	-2.52	N(3)	----	30,000	-.48	30	-2.52	200	-1.70	3,000	-.52
130	15	-2.82	N(30)	----	300	-1.52	N(3)	----	N(2)	----	500	-1.30	50	-2.30	N(3)	----	30,000	-.48	30	-2.52	300	-1.52	1,500	-.82
142	15	-2.82	N(30)	----	2	-3.70	5	-3.30	N(2)	----	300	-1.52	50	-2.30	N(3)	----	500	-1.30	70	-2.15	1,000	-1.00	3,000	-.52
161	10	-3.00	N(30)	----	150	-1.82	N(3)	----	N(2)	----	700	-1.15	70	-2.15	N(3)	----	10,000	-.00	200	-1.70	2,000	-.70	1,500	-.82
162	15	-2.82	N(30)	----	7	-3.15	N(3)	----	N(2)	----	100	-2.00	70	-2.15	N(3)	----	2,000	-.70	70	-2.15	1,000	-1.00	2,000	-.70
163	30	-2.52	N(30)	----	10	-3.00	N(3)	----	N(2)	----	1,000	-1.00	100	-2.00	N(3)	----	10,000	-.00	N(1)	----	700	-1.15	2,000	-.70
166	7	-3.15	N(30)	----	2	-3.70	N(3)	----	N(2)	----	500	-1.30	50	-2.30	N(3)	----	2,00							

TABLE 3.—Analytical data for oxidized silicified and argillized rock samples from the Combination-January cuts—Continued

Sample	Au		Ag		Pb		Bi		Hg		As		Cu		Zn		Mo		Ba		Be		Co	
	ppm	log %	ppm	log %	ppm	log %	ppm	log %	ppm	log %	ppm	log %	ppm	log %	ppm	log %	ppm	log %	ppm	log %	ppm	log %	ppm	log %
Silicified rocks—Continued																								
185	4.4	-3.36	1	-4.00	1,500	-0.82	N(5)	-----	0.10	-5.00	80	-2.10	20	-2.70	L(25)	-----	10	-3.00	700	-1.15	N(0.3)	-----	N(3)	-----
186	5.2	-3.28	2	-3.70	700	-1.15	15	-2.82	.10	-5.00	10	-3.00	30	-2.52	L(25)	-----	10	-3.00	500	-1.30	N(0.3)	-----	N(3)	-----
187	24	-2.62	2	-3.70	700	-1.15	N(5)	-----	.10	-5.00	60	-2.22	50	-2.30	L(25)	-----	3	-3.52	500	-1.30	N(0.3)	-----	N(3)	-----
188	7.4	-3.13	2	-3.70	700	-1.15	N(5)	-----	.10	-5.00	20	-2.70	7	-3.15	L(25)	-----	N(3)	-----	500	-1.30	N(0.3)	-----	N(3)	-----
189	.28	-4.55	3	-3.52	50	-2.30	N(5)	-----	.10	-5.00	10	-3.00	30	-2.52	50	-2.30	N(3)	-----	200	-1.70	N(0.3)	-----	N(3)	-----
190	.20	-4.70	2	-3.70	200	-1.70	N(5)	-----	.13	-4.89	10	-3.00	50	-2.30	L(25)	-----	10	-3.00	1,000	-1.00	N(0.3)	-----	N(3)	-----
191	2.1	-3.68	L(1)	-----	700	-1.15	N(5)	-----	.10	-5.00	10	-3.00	7	-3.15	L(25)	-----	N(3)	-----	1,000	-1.00	N(0.3)	-----	N(3)	-----
192	.58	-4.24	1	-4.00	300	-1.52	N(5)	-----	.15	-4.82	20	-2.70	30	-2.52	30	-2.52	7	-3.15	700	-1.15	N(0.3)	-----	N(3)	-----
193	1.0	-4.00	2	-3.70	500	-1.30	N(5)	-----	.17	-4.77	L(10)	-----	2	-3.70	L(25)	-----	N(3)	-----	700	-1.15	N(0.3)	-----	N(3)	-----
194	.80	-4.10	3	-3.52	7	-3.15	N(5)	-----	.10	-5.00	10	-3.00	15	-2.82	30	-2.52	3	-3.52	300	-1.52	N(0.3)	-----	N(3)	-----
195	1.4	-3.87	L(1)	-----	150	-1.82	N(5)	-----	.11	-4.96	10	-3.00	2	-3.70	L(25)	-----	N(3)	-----	700	-1.15	N(0.3)	-----	N(3)	-----
196	.20	-4.70	L(1)	-----	150	-1.82	N(5)	-----	.13	-4.89	10	-3.00	50	-2.30	L(25)	-----	3	-3.52	700	-1.15	N(0.3)	-----	N(3)	-----
197	7.5	-3.12	L(1)	-----	500	-1.30	N(5)	-----	.15	-4.82	10	-3.00	7	-3.15	50	-2.30	3	-3.52	500	-1.30	N(0.3)	-----	N(3)	-----
198	2.7	-3.57	L(1)	-----	700	-1.15	N(5)	-----	.08	-5.10	10	-3.00	30	-2.52	L(25)	-----	10	-3.00	500	-1.30	N(0.3)	-----	N(3)	-----
199	.40	-4.40	2	-3.70	70	-2.15	N(5)	-----	.10	-5.00	10	-3.00	7	-3.15	50	-2.30	5	-3.30	1,000	-1.00	N(0.3)	-----	N(3)	-----
200	.25	-4.60	3	-3.52	50	-2.30	N(5)	-----	.06	-5.22	10	-3.00	5	-3.30	L(25)	-----	N(3)	-----	500	-1.30	N(0.3)	-----	N(3)	-----
201	.90	-4.05	N(0.1)	-----	500	-1.30	N(5)	-----	.06	-5.22	L(10)	-----	7	-3.15	L(25)	-----	N(3)	-----	500	-1.30	N(0.3)	-----	N(3)	-----
220	.30	-4.52	N(0.1)	-----	200	-1.70	15	-2.82	.04	-5.40	160	-1.80	200	-1.70	60	-2.22	10	-3.00	500	-1.30	N(0.3)	-----	N(3)	-----
221	.40	-4.40	2	-3.70	70	-2.15	N(5)	-----	.11	-4.96	140	-1.85	7	-3.15	70	-2.15	N(3)	-----	700	-1.15	N(0.3)	-----	N(3)	-----
222	.98	-4.01	2	-3.70	70	-2.15	N(5)	-----	.10	-5.00	100	-2.00	30	-2.52	L(25)	-----	N(3)	-----	500	-1.30	N(0.3)	-----	N(3)	-----
223	.30	-4.52	L(1)	-----	200	-1.70	20	-2.70	.10	-5.00	60	-2.22	30	-2.52	L(25)	-----	N(3)	-----	300	-1.52	N(0.3)	-----	N(3)	-----
240	.10	-5.00	L(1)	-----	50	-2.30	N(5)	-----	.10	-5.00	10	-3.00	70	-2.15	L(25)	-----	N(3)	-----	1,000	-1.00	N(0.3)	-----	N(3)	-----
246	.37	-4.43	N(0.1)	-----	30	-2.30	N(5)	-----	.08	-5.10	10	-3.00	7	-3.15	L(25)	-----	N(3)	-----	700	-1.15	N(0.3)	-----	N(3)	-----
249	1.4	-3.85	L(1)	-----	30	-2.52	N(5)	-----	.10	-5.00	10	-3.00	7	-3.15	L(25)	-----	N(3)	-----	500	-1.30	N(0.3)	-----	N(3)	-----
250	1.2	-3.94	1.5	-3.82	50	-2.30	10	-3.00	.08	-5.10	10	-3.00	5	-3.30	L(25)	-----	N(3)	-----	1,000	-1.00	N(0.3)	-----	N(3)	-----
251	2.3	-3.64	3	-3.52	200	-1.70	30	-2.52	.10	-5.00	40	-2.40	10	-3.00	L(25)	-----	3	-3.52	1,000	-1.00	N(0.3)	-----	N(3)	-----
252	14	-2.85	1.5	-3.82	100	-2.00	15	-2.82	.10	-5.00	80	-2.10	70	-2.15	L(25)	-----	5	-3.30	1,000	-1.00	N(0.3)	-----	N(3)	-----
254	.58	-4.24	L(1)	-----	100	-2.00	N(5)	-----	.04	-5.40	120	-1.92	15	-2.82	L(25)	-----	5	-3.30	700	-1.15	N(0.3)	-----	10	-3.00
255	2.1	-3.68	10	-3.00	300	-1.52	30	-2.52	.10	-5.00	80	-2.10	50	-2.30	L(25)	-----	7	-3.15	500	-1.30	N(0.3)	-----	N(3)	-----
256	3.4	-3.47	30	-2.52	300	-1.52	30	-2.52	.10	-5.00	120	-1.92	150	-1.82	40	-2.40	7	-3.15	700	-1.15	N(0.3)	-----	N(3)	-----
257	3.3	-3.48	7	-3.15	500	-1.30	20	-2.70	.20	-4.70	10	-3.00	30	-2.52	40	-2.40	N(3)	-----	700	-1.15	N(0.3)	-----	N(3)	-----
258	4.3	-3.37	50	-2.30	700	-1.15	200	-1.70	.29	-4.54	140	-1.85	200	-1.70	50	-2.30	10	-3.00	500	-1.30	N(0.3)	-----	N(3)	-----
259	1.2	-3.92	30	-2.52	300	-1.52	30	-2.52	.23	-4.64	10	-3.00	70	-2.15	L(25)	-----	3	-3.52	500	-1.30	N(0.3)	-----	N(3)	-----
260	1.3	-3.92	N(0.1)	-----	300	-1.52	30	-2.52	.10	-5.00	60	-2.22	30	-2.52	L(25)	-----	3	-3.52	700	-1.15	N(0.3)	-----	N(3)	-----
261	2.9	-3.54	N(0.1)	-----	200	-1.70	30	-2.52	.12	-4.92	160	-1.80	70	-2.15	40	-2.40	10	-3.00	1,000	-1.00	N(0.3)	-----	N(3)	-----
262	1.1	-3.98	N(0.1)	-----	100	-2.00	30	-2.52	.19	-4.72	80	-2.10	15	-2.82	L(25)	-----	10	-3.00	700	-1.15	N(0.3)	-----	N(3)	-----
263	1.8	-3.74	N(0.1)	-----	200	-1.70	N(5)	-----	.13	-4.89	10	-3.00	50	-2.30	L(25)	-----	5	-3.30	1,000	-1.00	N(0.3)	-----	N(3)	-----
264	2.1	-3.68	1	-4.00	500	-1.30	20	-2.70	.20	-4.70	10	-3.00	7	-3.15	30	-2.52	N(3)	-----	700	-1.15	N(0.3)	-----	N(3)	-----
265	1.6	-3.81	15	-2.82	100	-2.00	30	-2.52	.24	-4.62	40	-2.40	20	-2.70	L(25)	-----	N(3)	-----	700	-1.15	N(0.3)	-----	N(3)	-----
266	5.4	-3.27	1	-3.82	1,000	-1.00	70	-2.15	.18	-4.74	80	-2.10	50	-2.30	L(25)	-----	10	-3.00	700	-1.15	N(0.3)	-----	N(3)	-----
267	4.2	-3.38	20	-2.70	500	-1.30	70	-2.15	1.00	-4.00	100	-2.00	70	-2.15	L(25)	-----	7	-3.15	700	-1.15	N(0.3)	-----	N(3)	-----
268	5.3	-3.28	30	-2.52	200	-1.70	70	-2.15	.64	-4.19	L(10)	-----	30	-2.52	L(25)	-----	3	-3.52	700	-1.15	N(0.3)	-----	N(3)	-----
269	2.3	-3.65	5	-3.30	150	-1.82	10	-3.00	.17	-4.77	10	-3.00	10	-3.00	L(25)	-----	3	-3.52	700	-1.15	N(0.3)	-----	N(3)	-----
270	4.3	-3.37	30	-2.52	100	-2.00	30	-2.52	.68	-4.17	10	-3.00	15	-2.82	30	-2.52	N(3)	-----	700	-1.15	N(0.3)	-----	N(3)	-----
271	19	-2.73	30	-2.52	300	-1.52	70	-2.15	.12	-4.92	10	-3.00	20	-2.70	40	-2.40	3	-3.52	500	-1.30	N(0.3)	-----	N(3)	-----
272	4.0	-3.40	2	-3.70	200	-1.70	50	-2.30	.15	-4.82	10	-3.00	15	-2.82	L(25)	-----	N(3)	-----	700	-1.15	N(0.3)	-----	N(3)	-----
273	2.7	-3.57	2	-3.70	50	-2.30	N(5)	-----	.24	-4.62	120	-1.92	150	-1.82	L(25)	-----	15	-2.82	500	-1.30	N(0.3)	-----	15	-2.82
274	.15	-4.82	L(1)	-----	200	-1.70	N(5)	-----	.06	-5.22	10	-3.00	15	-2.82	L(25)	-----	N(3)	-----	3,000	-0.52	N(0.3)	-----	N(3)	-----
275	.49	-4.31	L(1)	-----	100	-2.00	N(5)	-----	.10	-5.00	10	-3.00	2	-3.70	L(25)	-----	N(3)	-----	500	-1.30	N(0.3)	-----	N(3)	-----
276	.70	-4.15	2	-3.70	300	-1.52	N(5)	-----	.19	-4.72	120	-1.92	10	-3.00	L(25)	-----	5	-3.30	500	-1.30	N(0.3)	-----	N(3)	-----
277	.57	-4.24	2	-3.70	70	-2.15	10	-3.00	.30	-4.52	20	-2.70	15	-2.82	L(25)	-----	N(3)	-----	500	-1.30	N(0.3)	-----	N(3)	-----
278	.81	-4.09	2	-3.70	50	-2.30	10	-3.00	.30	-4.52	40	-2.40	20	-2.70	L(25)	-----	N(3)	-----	500	-1.30	N(0.3)	-----	N(3)	-----
Argillized rocks																								
12	.19	-4.72	N(0.1)	-----	30	-2.52	N(5)	-----	.10	-														

Sample	Cr		La		Mn		Nb		Ni		Sr		V		Y		Fe		Mg		Ca		Ti	
	ppm	log %	ppm	log %	ppm	log %	ppm	log %	ppm	log %	ppm	log %	ppm	log %	ppm	log %	ppm	log %	ppm	log %	ppm	log %	ppm	log %
Silicified rocks — Continued																								
185	50	-2.30	N(30)	----	100	-2.00	N(3)	----	N(2)	----	700	-1.15	30	-2.52	N(3)	----	10,000	0.00	100	-2.00	500	-1.30	1,500	-0.82
186	15	-2.82	N(30)	----	15	-2.82	N(3)	----	N(2)	----	500	-1.30	70	-2.15	N(3)	----	30,000	.48	150	-1.82	500	-1.30	3,000	-.52
187	15	-2.82	N(30)	----	15	-2.82	N(3)	----	N(2)	----	700	-1.15	70	-2.15	N(3)	----	20,000	.30	150	-1.82	1,000	-1.00	2,000	-.70
188	5	-3.30	N(30)	----	5	-3.30	N(3)	----	N(2)	----	500	-1.30	30	-2.52	N(3)	----	3,000	-.52	100	-2.00	700	-1.15	2,000	-.70
189	5	-3.30	N(30)	----	5	-3.30	5	-3.30	N(2)	----	70	-2.15	20	-2.70	N(3)	----	2,000	-.70	100	-2.00	70	-2.15	3,000	-.52
190	20	-2.70	50	-2.30	15	-2.82	3	-3.52	N(2)	----	1,500	-.82	70	-2.15	N(3)	----	20,000	-.30	70	-2.15	1,000	-1.00	2,000	-.70
191	15	-2.82	30	-2.52	10	-3.00	3	-3.52	N(2)	----	300	-1.52	70	-2.15	N(3)	----	5,000	-.30	100	-2.00	1,000	-1.00	2,000	-.70
192	20	-2.70	N(30)	----	1	-4.00	3	-3.52	N(2)	----	1,500	-.82	70	-2.15	N(3)	----	20,000	-.30	200	-1.70	1,000	-1.00	1,500	-.82
193	20	-2.70	N(30)	----	5	-3.30	3	-3.52	N(2)	----	700	-1.15	50	-2.30	N(3)	----	1,000	-1.00	70	-2.15	500	-1.30	2,000	-.70
194	N(2)	----	N(30)	----	N(1)	----	5	-3.30	N(2)	----	70	-2.15	15	-2.82	N(3)	----	5,000	-.30	100	-2.00	150	-1.82	2,000	-.70
195	15	-2.82	30	-2.52	5	-3.30	N(3)	----	N(2)	----	150	-1.82	70	-2.15	10	-3.00	2,000	-.70	70	-2.15	700	-1.15	3,000	-.52
196	15	-2.82	N(30)	----	100	-2.00	N(3)	----	N(2)	----	500	-1.30	70	-2.15	10	-3.00	20,000	-.30	150	-1.82	300	-1.52	3,000	-.52
197	30	-2.52	N(30)	----	50	-2.30	N(3)	----	N(2)	----	500	-1.30	70	-2.15	N(3)	----	10,000	.00	100	-2.00	700	-1.15	3,000	-.52
198	30	-2.52	N(30)	----	7	-3.15	N(3)	----	N(2)	----	700	-1.15	70	-2.15	10	-3.00	20,000	.30	200	-1.70	700	-1.15	3,000	-.52
199	30	-2.52	50	-2.30	20	-2.70	N(3)	----	N(2)	----	100	-2.00	70	-2.15	30	-2.52	30,000	.48	200	-1.70	700	-1.15	3,000	-.52
200	30	-2.52	30	-2.52	3	-3.52	N(3)	----	N(2)	----	700	-1.15	70	-2.15	N(3)	----	3,000	-.52	100	-2.00	700	-1.15	3,000	-.52
201	20	-2.70	N(30)	----	150	-1.82	N(3)	----	N(2)	----	700	-1.15	70	-2.15	N(3)	----	3,000	-.52	70,000	.85	1,000	-1.00	3,000	-.52
220	20	-2.70	50	-2.30	70	-2.15	N(3)	----	N(2)	----	700	-1.15	70	-2.15	N(3)	----	100,000	1.00	300	-1.52	5,000	-.30	2,000	-.70
221	20	-2.70	N(30)	----	2	-3.70	10	-3.00	N(2)	----	700	-1.15	20	-2.70	N(3)	----	2,000	-.70	50	-2.30	500	-1.30	3,000	-.52
222	10	-3.00	N(30)	----	2	-3.70	3	-3.52	N(2)	----	200	-1.70	30	-2.52	N(3)	----	2,000	-.70	7	-3.15	150	-1.82	2,000	-.70
223	20	-2.70	N(30)	----	3	-3.52	N(3)	----	N(2)	----	500	-1.30	50	-2.30	N(3)	----	1,000	-1.00	7	-3.15	500	-1.30	3,000	-.52
240	30	-2.52	50	-2.30	10	-3.00	7	-3.15	N(2)	----	500	-1.30	70	-2.15	N(3)	----	7,000	-.15	70	-2.15	700	-1.15	2,000	-.70
246	30	-2.52	70	-2.15	20	-2.70	7	-3.15	N(2)	----	1,500	-.82	70	-2.15	15	-2.82	30,000	.48	1,000	-1.00	700	-1.15	3,000	-.52
249	30	-2.52	N(30)	----	5	-3.30	7	-3.15	N(2)	----	500	-1.30	70	-2.15	N(3)	----	3,000	-.52	50	-2.30	700	-1.15	3,000	-.52
250	30	-2.52	50	-2.30	5	-3.30	5	-3.30	N(2)	----	1,000	-1.00	70	-2.15	N(3)	----	5,000	-.30	50	-2.30	1,500	-.82	3,000	-.52
251	30	-2.52	N(30)	----	10	-3.00	5	-3.30	N(2)	----	700	-1.15	70	-2.15	N(3)	----	15,000	.18	50	-2.30	700	-1.15	3,000	-.52
252	30	-2.52	50	-2.30	10	-3.00	5	-3.30	N(2)	----	1,000	-1.00	70	-2.15	N(3)	----	15,000	.18	70	-2.15	1,500	-.82	3,000	-.52
254	20	-2.70	50	-2.30	30	-2.52	7	-3.15	N(2)	----	700	-1.15	70	-2.15	N(3)	----	15,000	.18	70	-2.15	500	-1.30	3,000	-.52
255	10	-3.00	N(30)	----	200	-1.70	N(3)	----	N(2)	----	500	-1.30	150	-1.82	N(3)	----	50,000	.70	200	-1.70	700	-1.15	2,000	-.70
256	10	-3.00	N(30)	----	50	-2.30	5	-3.30	N(2)	----	500	-1.30	70	-2.15	N(3)	----	30,000	.48	150	-1.82	700	-1.15	2,000	-.70
257	20	-2.70	N(30)	----	5	-2.30	5	-3.30	N(2)	----	1,000	-1.00	50	-2.30	N(3)	----	3,000	-.52	50	-2.30	700	-1.15	3,000	-.52
258	30	-2.52	N(30)	----	70	-2.15	N(3)	----	N(2)	----	1,000	-1.00	70	-2.15	N(3)	----	70,000	.85	300	-1.52	1,000	-1.00	1,500	-.82
259	30	-2.52	N(30)	----	7	-3.15	N(3)	----	N(2)	----	700	-1.15	70	-2.15	N(3)	----	15,000	.18	70	-2.15	500	-1.30	3,000	-.52
260	30	-2.52	50	-2.30	700	-1.15	5	-3.30	N(2)	----	1,500	-.82	50	-2.30	N(3)	----	15,000	.18	100	-2.00	700	-1.15	3,000	-.52
261	20	-2.70	50	-2.30	1,000	-1.00	5	-3.30	N(2)	----	1,000	-1.00	150	-1.82	N(3)	----	20,000	.30	200	-1.70	1,000	-1.00	3,000	-.52
262	50	-2.30	50	-2.30	700	-1.15	5	-3.30	N(2)	----	300	-1.52	70	-2.15	N(3)	----	20,000	.30	150	-1.82	500	-1.30	3,000	-.52
263	30	-2.52	50	-2.30	1,000	-1.00	5	-3.30	N(2)	----	1,500	-.82	100	-2.00	N(3)	----	10,000	.00	100	-2.00	5,000	-.30	3,000	-.52
264	20	-2.70	50	-2.30	50	-2.30	5	-3.30	N(2)	----	700	-1.15	100	-2.00	N(3)	----	5,000	-.30	150	-1.82	1,500	-.82	3,000	-.52
265	15	-2.82	N(30)	----	15	-2.82	5	-3.30	N(2)	----	300	-1.52	50	-2.30	N(3)	----	10,000	.00	100	-2.00	500	-1.30	3,000	-.52
266	20	-2.70	N(30)	----	30	-2.52	3	-3.52	N(2)	----	1,000	-1.00	70	-2.15	N(3)	----	20,000	.30	150	-1.82	1,000	-1.00	2,000	-.70
267	20	-2.70	50	-2.30	100	-2.00	N(3)	----	N(2)	----	1,000	-1.00	70	-2.15	N(3)	----	30,000	.48	150	-1.82	1,000	-1.00	3,000	-.52
268	20	-2.70	50	-2.30	30	-2.52	3	-3.52	N(2)	----	300	-1.52	70	-2.15	N(3)	----	10,000	.00	150	-1.82	1,000	-1.00	3,000	-.52
269	30	-2.52	50	-2.30	7	-3.15	N(3)	----	N(2)	----	500	-1.30	100	-2.00	N(3)	----	10,000	.00	150	-1.82	2,000	-.70	3,000	-.52
270	20	-2.70	N(30)	----	5	-3.30	N(3)	----	N(2)	----	300	-1.52	50	-2.30	N(3)	----	7,000	-.15	100	-2.00	1,000	-1.00	3,000	-.52
271	20	-2.70	N(30)	----	7	-3.15	N(3)	----	N(2)	----	300	-1.52	70	-2.15	N(3)	----	5,000	-.30	100	-2.00	1,500	-.82	3,000	-.52
272	20	-2.70	N(30)	----	5	-3.30	N(3)	----	N(2)	----	700	-1.15	70	-2.15	N(3)	----	7,000	-.15	100	-2.00	1,500	-.82	3,000	-.52
273	20	-2.70	N(30)	----	300	-1.52	5	-3.30	N(2)	----	70	-2.15	70	-2.15	N(3)	----	70,000	.85	500	-1.30	300	-1.52	3,000	-.52
274	20	-2.70	N(30)	----	10	-3.00	5	-3.30	N(2)	----	700	-1.15	50	-2.30	N(3)	----	5,000	-.30	200	-1.70	700	-1.15	3,000	-.52
275	20	-2.70	N(30)	----	7	-3.15	5	-3.30	N(2)	----	300	-1.52	100	-2.00	N(3)	----	2,000	-.70	200	-1.70	1,500	-.82	3,000	-.52
276	20	-2.70	N(30)	----	15	-2.82	5	-3.30	N(2)	----	700	-1.15	100	-2.00	N(3)	----	30,000	.48	300	-1.52	500	-1.30	3,000	-.52
277	20	-2.70	N(30)	----	5	-3.30	N(3)	----	N(2)	----	1,000	-1.00	70	-2.15	N(3)	----	20,000	.30	100	-2.00	500	-1.30	3,000	-.52
278	20	-2.70	N(30)	----	7	-3.15	N(3)	----	N(2)	----	700	-1.15	70	-2.15	N(3)	----	15,000	.18	100	-2.00	1,500	-.82	3,000	-.52
Argillized rocks — Continued																								
12	20	-2.70	100	-2.00	200	-1.70	N(3)	----	N(2)	----	500	-1.30	150	-1.82	10	-3.00	70,000	.85	5,000	-.30	5,000	-.30	2,000	-.70
13	20	-2.70	N(30)	----	500	-1.30	N(3)	----	N(2)	----	300	-1.52	150	-1.82	10	-3.00	30,000	.48	5,000	-.30	5,000	-.30	3,000	-.52
14	20	-2.70	N(30)	----	100	-2.00	N(3)	----	N(2)	----	700	-1.15	100	-2.00	N(3)	----	3,000	-.52	7,000	-.15	5,000	-.30	3,000	-.52
15	15	-2.82	N(30)	----	300	-1.52	N(3)	----	N(2)	----	500	-1.30	100	-2.00	N(3)	----	20,000	.30	5,000	-.30	5,000	-.30	3,000	-.52
16	20	-2.70	30	-2.52	2,000	-0.70	5	-3.30	5	-3.30	500	-1.30	100	-2.00	10	-3.00	20,000	.30	3,000	-.30	15,000	-.82	5,000	-.30
17	20	-2.70	50	-2.30	3,000	-.52	N(3)	----	5	-3.30	700	-1.15	70	-2.15	7	-3.15	15,000	.18	7,000	-.15	7,000	-.15	3,000	

TABLE 3.—Analytical data for oxidized silicified and argillized rock samples from the Combination-January cuts—Continued

Sample	Au		Ag		Pb		Bi		Hg		As		Cu		Zn		Mo		Ba		Be		Co	
	ppm	log %	ppm	log %	ppm	log %	ppm	log %	ppm	log %	ppm	log %	ppm	log %	ppm	log %	ppm	log %	ppm	log %	ppm	log %	ppm	log %
Argillized rocks—Continued																								
42	0.10	-5.00	0.2	-4.70	10	-3.00	N(5)	-----	0.10	-5.00	L(10)	-----	70	-2.15	L(25)	-----	N(3)	-----	1,500	-0.82	2	-3.70	7	-3.15
43	L(0.1)	-----	.2	-4.70	7	-3.15	N(5)	-----	.10	-5.00	L(10)	-----	10	-3.00	L(25)	-----	N(3)	-----	1,500	-.82	1	-4.00	7	-3.15
44	.10	-5.00	.2	-4.70	5	-3.30	N(5)	-----	.06	-5.22	L(10)	-----	20	-2.70	L(25)	-----	N(3)	-----	700	-1.15	.7	-4.15	5	-3.30
46	L(0.1)	-----	.2	-4.70	50	-2.30	N(5)	-----	.06	-5.22	L(10)	-----	10	-3.00	L(25)	-----	N(3)	-----	500	-1.30	2	-3.70	N(3)	-----
47	L(0.1)	-----	.2	-4.70	7	-3.15	N(5)	-----	.06	-5.22	10	-3.00	20	-2.70	L(25)	-----	N(3)	-----	1,000	-1.00	1.5	-3.82	5	-3.30
48	.10	-5.00	.2	-4.70	5	-3.30	N(5)	-----	.08	-5.10	10	-3.00	50	-2.30	L(25)	-----	N(3)	-----	1,000	-1.00	1	-4.00	5	-3.30
49	L(0.1)	-----	.2	-4.70	7	-3.15	N(5)	-----	.10	-5.00	10	-3.00	30	-2.52	L(25)	-----	N(3)	-----	1,500	-.82	.7	-4.15	5	-3.30
50	.10	-5.00	.2	-4.70	7	-3.15	N(5)	-----	.04	-5.40	L(10)	-----	20	-2.70	L(25)	-----	N(3)	-----	1,000	-1.00	.7	-4.15	5	-3.30
51	L(0.1)	-----	.2	-4.70	10	-3.00	N(5)	-----	.11	-4.96	L(10)	-----	15	-2.82	L(25)	-----	N(3)	-----	1,500	-.82	.5	-4.30	5	-3.30
52	.36	-4.44	.3	-4.52	2	-3.70	N(5)	-----	.08	-5.10	40	-2.40	10	-3.00	L(25)	-----	3	-3.52	100	-2.00	3	-4.52	5	-3.30
53	L(0.1)	-----	.5	-4.30	15	-2.82	N(5)	-----	.08	-5.10	L(10)	-----	30	-2.52	40	-2.40	3	-3.52	1,000	-1.00	3	-4.52	7	-3.15
54	L(0.1)	-----	.3	-4.52	10	-3.00	N(5)	-----	.08	-5.10	10	-3.00	20	-2.70	30	-2.52	50	-2.30	2,000	-.70	3	-4.52	10	-3.00
55	L(0.1)	-----	.3	-4.52	10	-3.00	N(5)	-----	.08	-5.10	L(10)	-----	50	-2.30	L(25)	-----	7	-3.15	1,000	-1.00	.3	-4.52	10	-3.00
56	.10	-5.00	.3	-4.52	15	-2.82	N(5)	-----	.08	-5.10	10	-3.00	30	-2.52	80	-2.10	5	-3.30	1,500	-.82	3	-4.52	5	-3.30
57	L(0.1)	-----	.3	-4.52	10	-3.00	N(5)	-----	.06	-5.22	10	-3.00	20	-2.70	80	-2.10	3	-3.52	1,500	-.82	3	-4.52	7	-3.15
58	.10	-5.00	.3	-4.52	5	-3.30	N(5)	-----	.08	-5.10	10	-3.00	30	-2.52	80	-2.10	5	-3.30	1,000	-1.00	.3	-4.52	7	-3.15
59	L(0.1)	-----	.3	-4.52	7	-3.15	N(5)	-----	.08	-5.10	10	-3.00	50	-2.30	80	-2.10	5	-3.30	1,000	-1.00	.5	-4.30	5	-3.30
60	L(0.1)	-----	.2	-4.70	2	-3.70	N(5)	-----	.04	-5.40	10	-3.00	30	-2.52	80	-2.10	N(3)	-----	1,000	-1.00	.7	-4.15	N(3)	-----
61	.20	-4.70	.7	-4.15	2	-3.70	N(5)	-----	.06	-5.22	10	-3.00	20	-2.70	80	-2.10	N(3)	-----	300	-1.52	2	-3.70	N(3)	-----
62	.10	-5.00	.2	-4.70	70	-2.15	N(5)	-----	.08	-5.10	80	-2.10	15	-2.82	80	-2.10	10	-3.00	1,000	-1.00	1	-4.00	N(3)	-----
70	.10	-5.00	N(0.1)	-----	N(2)	-----	N(5)	-----	.06	-5.22	40	-2.40	10	-3.00	L(25)	-----	3	-3.52	2,000	-.70	1	-4.00	N(3)	-----
71	.10	-5.00	N(0.1)	-----	N(2)	-----	N(5)	-----	.06	-5.22	10	-3.00	10	-3.00	L(25)	-----	N(3)	-----	700	-1.15	N(0.3)	-----	N(3)	-----
72	.10	-5.00	N(0.1)	-----	.20	-2.70	N(5)	-----	.06	-5.22	10	-3.00	20	-2.70	L(25)	-----	N(3)	-----	1,500	-.82	N(0.3)	-----	N(3)	-----
73	1.5	-3.83	N(0.1)	-----	N(2)	-----	N(5)	-----	.04	-5.40	10	-3.00	15	-2.82	L(25)	-----	5	-3.30	1,500	-.82	N(0.3)	-----	N(3)	-----
76	.18	-4.74	N(0.1)	-----	.7	-3.15	N(5)	-----	.17	-4.77	120	-1.92	7	-3.15	L(25)	-----	5	-3.30	1,000	-1.00	N(0.3)	-----	N(3)	-----
93	4.1	-3.39	.3	-4.52	200	-1.70	N(5)	-----	.11	-4.96	60	-2.22	50	-2.30	40	-2.40	20	-2.70	300	-1.52	1	-4.00	3	-3.52
94	.10	-5.00	.5	-4.30	50	-2.30	N(5)	-----	.08	-5.10	40	-2.40	20	-2.70	30	-2.52	10	-3.00	3,000	-.52	1	-4.00	N(3)	-----
95	.10	-5.00	.3	-4.52	30	-2.52	N(5)	-----	.04	-5.40	20	-2.70	30	-2.52	30	-2.52	10	-3.00	700	-1.15	1	-4.00	N(3)	-----
96	.10	-5.00	.3	-4.52	20	-2.70	N(5)	-----	.10	-5.00	10	-3.00	50	-2.30	40	-2.40	10	-3.00	2,000	-1.00	1	-4.00	N(3)	-----
97	1.9	-3.73	.3	-4.52	150	-1.82	N(5)	-----	.20	-4.70	20	-2.70	7	-3.15	30	-2.52	15	-2.82	2,000	-1.00	1	-4.00	N(3)	-----
98	.20	-4.70	.3	-4.52	100	-2.00	N(5)	-----	.20	-4.70	10	-3.00	10	-3.00	L(25)	-----	3	-3.52	1,000	-1.00	.7	-4.15	N(3)	-----
99	.19	-4.72	.3	-4.52	30	-2.52	N(5)	-----	.10	-5.00	10	-3.00	30	-2.52	30	-2.52	7	-3.15	700	-1.15	.7	-4.15	N(3)	-----
100	.10	-5.00	.3	-4.52	30	-2.52	N(5)	-----	.10	-5.00	10	-3.00	15	-2.82	L(25)	-----	7	-3.15	2,000	-1.00	1.5	-3.82	N(3)	-----
102	.10	-5.00	.7	-4.15	200	-1.70	N(5)	-----	.10	-5.00	10	-3.00	7	-3.15	L(25)	-----	5	-3.30	1,000	-1.00	1	-4.00	N(3)	-----
103	.48	-4.32	1	-4.00	200	-1.70	N(5)	-----	.10	-5.00	10	-3.00	30	-2.52	40	-2.40	5	-3.30	300	-1.52	.7	-4.15	3	-3.52
104	L(0.1)	-----	.5	-4.30	200	-1.70	N(5)	-----	.04	-4.40	10	-3.00	30	-2.52	40	-2.40	7	-3.15	500	-1.30	.7	-4.15	3	-3.52
105	.10	-5.00	1.5	-3.82	70	-2.15	N(5)	-----	.20	-4.70	20	-2.70	10	-3.00	30	-2.52	3	-3.52	200	-1.70	1	-4.00	3	-3.52
106	.10	-5.00	.5	-4.30	15	-2.82	N(5)	-----	.10	-5.00	10	-3.00	7	-3.15	L(25)	-----	3	-3.52	700	-1.15	1.5	-3.82	3	-3.52
107	.20	-4.70	.3	-4.52	20	-2.70	N(5)	-----	.10	-5.00	10	-3.00	20	-2.70	40	-2.40	3	-3.52	1,000	-1.00	1	-4.00	3	-3.52
108	.10	-5.00	.7	-4.15	15	-2.82	N(5)	-----	.10	-5.00	10	-3.00	20	-2.70	80	-2.10	3	-3.52	1,500	-.82	.7	-4.15	5	-3.30
109	L(0.1)	-----	.5	-4.30	10	-3.00	N(5)	-----	.10	-5.00	10	-3.00	30	-2.52	280	-1.55	10	-3.00	2,000	-1.00	1	-4.00	10	-3.00
110	.17	-4.77	.3	-4.52	10	-3.00	N(5)	-----	.10	-5.00	40	-2.40	30	-2.52	175	-1.76	10	-3.00	1,000	-1.00	1.5	-3.82	15	-2.82
111	.10	-5.00	.3	-4.52	7	-3.15	N(5)	-----	.10	-5.00	10	-3.00	20	-2.70	L(25)	-----	5	-3.30	2,000	-1.00	1	-4.00	10	-3.00
112	.10	-5.00	N(0.1)	-----	7	-3.15	N(5)	-----	.10	-5.00	20	-2.70	10	-3.00	L(25)	-----	5	-3.30	1,000	-1.00	1.5	-3.82	10	-3.00
113	.10	-5.00	N(0.1)	-----	7	-3.15	N(5)	-----	.10	-5.00	20	-2.70	10	-3.00	70	-2.15	5	-3.30	700	-1.15	1	-4.00	7	-3.15
114	.10	-5.00	N(0.1)	-----	7	-3.15	N(5)	-----	.10	-5.00	100	-2.00	30	-2.52	50	-2.30	7	-3.15	700	-1.15	1	-4.00	7	-3.15
115	.15	-4.82	N(0.1)	-----	7	-3.15	N(5)	-----	.10	-5.00	L(10)	-----	30	-2.52	80	-2.10	5	-3.30	700	-1.15	1	-4.00	7	-3.15
122	L(0.1)	-----	L(1)	-----	50	-2.30	N(5)	-----	.10	-5.00	20	-2.70	30	-2.52	50	-2.30	10	-3.00	70	-2.15	1	-4.00	N(3)	-----
123	L(0.1)	-----	L(1)	-----	70	-2.15	N(5)	-----	.04	-5.40	10	-3.00	5	-3.30	L(25)	-----	5	-3.30	300	-1.52	1	-4.00	N(3)	-----
124	.37	-4.43	N(0.1)	-----	N(2)	-----	N(5)	-----	.04	-5.40	10	-3.00	3	-3.52	L(25)	-----	N(3)	-----	200	-1.70	1	-4.00	N(3)	-----
125	.10	-5.00	N(0.1)	-----	7	-3.15	N(5)	-----	.04	-5.40	10	-3.00	15	-2.82	25	-2.60	N(3)	-----	200	-1.70	1	-4.00	N(3)	-----
126	.16	-4.80	N(0.1)	-----	10	-3.00	N(5)	-----	.10	-5.00	10	-3.00	7	-3.15	30	-2.52	N(3)	-----	1,500	-.82	1	-4.00	N(3)	-----
127	.50	-4.30	N(0.1)	-----	50	-2.30	N(5)	-----	.10	-5.00	10	-3.00	10	-3.00	50	-2.30	N(3)	-----	500	-1.30	N(0.3)	-----	N(3)	-----
128	L(0.1)	-----	N(0.1)	-----	20	-2.70	N(5)	-----	.10	-5.00	20	-2.70	30	-2.52	80	-2.10	5	-3.30	1,500	-.82	N(0.3)	-----	10	-3.00
131	L(0.1)	-----	N(0.1)	-----	50	-2.30	N(5)	-----	.04	-5.40	20	-2.70	30	-2.52	40	-2.40	5	-3.30	1,000	-1.00	N(0.3)	-----	7	-3.15
132	L(0.1)	-----	L(1)	-----	50	-2.30	N(5)	-----	.06	-5.22	20	-2.70	70	-2.15	90	-2.05	10	-3.00	150	-1.82	N(0.3)	-----	7	-3.15
133	L(0.1)	-----	N(0.1)	-----	70	-2.15	N(5)	-----	.04	-5.40	10	-3.00	20	-2.70	40	-2.40	N(3)	-----	1,500	-.82	N(0.3)	-----	N(3)	-----
134	.20	-4.70	L(1)	-----	50	-2.30	N(5)	-----	.04	-5.40	120	-1.92	20	-2.70	90	-2.05	5	-3.30	1,500	-.82	N(0.3)	-----	N(3)	-----
135	L(0.1)	-----	N(0.1)	-----	7	-3.15	N(5)	-----	.06	-5.22	10	-3.00	10	-3.00	40	-2.40	5	-3.30	1,500	-.82	N(0.3)	-----	N(3)	-----
136	L(0.1)	-----	1	-4.00	70																			

Sample	Cr	La	Mn	Nb	Ni	Sr	V	Y	Fe	Mg	Ca	Ti												
	ppm	log %	ppm	log %	ppm	log %	ppm	log %	ppm	log %	ppm	log %												
Argillized rocks — Continued																								
42	20	-2.70	50	-2.30	70	-2.15	N(3)	----	N(2)	----	1,500	-0.82	100	-2.00	30	-2.52	50,000	0.70	3,000	-0.52	700	-1.15	3,000	-0.52
43	30	-2.52	50	-2.30	30	-2.52	N(3)	----	7	-3.15	500	-1.30	100	-2.00	20	-2.70	20,000	.30	3,000	-.52	700	-1.15	5,000	-.30
44	20	-2.70	70	-2.15	100	-2.00	N(3)	----	3	-3.52	200	-1.70	100	-2.00	15	-2.82	30,000	.48	7,000	-.15	700	-1.15	5,000	-.30
46	20	-2.70	100	-2.00	100	-2.00	5	-3.30	N(2)	----	1,000	-1.00	100	-2.00	15	-2.82	2,000	-.70	7,000	-.15	1,500	-.82	5,000	-.30
47	20	-2.70	50	-2.30	30	-2.52	N(3)	----	3	-3.52	700	-1.15	70	-2.15	7	-3.15	30,000	.48	2,000	-.70	1,000	-1.00	3,000	-.52
48	20	-2.70	70	-2.15	50	-2.30	N(3)	----	3	-3.52	1,500	-.82	70	-2.15	10	-3.00	20,000	.30	2,000	-.70	2,000	-1.00	7,000	-.52
49	30	-2.52	70	-2.15	50	-2.30	5	-3.30	3	-3.52	700	-1.15	100	-2.00	10	-3.00	20,000	.30	2,000	-.70	1,000	-1.00	5,000	-.30
50	20	-2.70	70	-2.15	30	-2.52	10	-3.00	N(2)	----	500	-1.30	100	-2.00	7	-3.15	15,000	.18	2,000	-.70	1,000	-1.00	5,000	-.30
51	30	-2.52	100	-2.00	20	-2.70	N(3)	----	2	-3.70	700	-1.15	100	-2.00	7	-3.15	7,000	-.15	2,000	-.70	2,000	-1.00	5,000	-.30
52	10	-3.00	N(30)	----	70	-2.15	N(3)	----	2	-3.70	150	-1.82	50	-2.30	5	-3.30	50,000	.7	1,000	-1.00	100	-2.00	2,000	-.70
53	30	-2.52	150	-1.82	200	-1.70	N(3)	----	2	-3.70	700	-1.15	70	-2.15	7	-3.15	30,000	.48	3,000	-.52	1,000	-1.00	3,000	-.52
54	30	-2.52	50	-2.30	150	-1.82	5	-3.30	3	-3.52	200	-1.70	100	-2.00	15	-2.82	70,000	.85	5,000	-.30	1,000	-1.00	5,000	-.30
55	30	-2.52	70	-2.15	200	-1.70	5	-3.30	5	-3.30	700	-1.15	100	-2.00	7	-3.15	70,000	.85	5,000	-.30	1,000	-1.00	5,000	-.30
56	30	-2.52	100	-2.00	150	-1.82	5	-3.30	N(2)	----	700	-1.15	70	-2.15	10	-3.00	50,000	.70	3,000	-.52	1,000	-1.00	5,000	-.30
57	30	-2.52	50	-2.30	100	-2.00	5	-3.30	2	-3.70	500	-1.30	70	-2.15	7	-3.15	30,000	.48	3,000	-.52	1,000	-1.00	5,000	-.30
58	30	-2.70	70	-2.15	70	-2.15	N(3)	----	5	-3.30	1,000	-1.00	70	-2.15	7	-3.15	50,000	.70	3,000	-.52	700	-1.15	5,000	-.30
59	20	-2.52	100	-2.00	100	-2.00	N(3)	----	10	-3.00	1,000	-1.00	100	-2.00	7	-3.15	50,000	.70	3,000	-.52	700	-1.15	3,000	-.52
60	15	-2.82	50	-2.30	100	-2.00	5	-3.30	2	-3.70	100	-2.00	50	-2.30	7	-3.15	10,000	.00	7,000	-.15	700	-1.15	5,000	-.30
61	20	-2.70	70	-2.15	100	-2.00	5	-3.30	3	-3.52	500	-1.30	100	-2.00	30	-2.52	20,000	.30	7,000	-.15	700	-1.15	3,000	-.52
62	30	-2.52	50	-2.30	200	-1.70	N(3)	----	5	-3.30	1,500	-.82	100	-2.00	20	-2.70	70,000	.85	5,000	-.30	1,000	-1.00	2,000	-.70
70	20	-2.70	70	-2.15	30	-2.52	N(3)	----	N(2)	----	300	-1.52	100	-2.00	20	-2.70	20,000	.30	5,000	-.30	1,000	-1.00	3,000	-.52
71	15	-2.82	70	-2.15	20	-2.70	N(3)	----	N(2)	----	500	-1.30	70	-2.15	20	-2.70	10,000	.00	1,500	-.82	700	-1.15	3,000	-.52
72	20	-2.70	70	-2.15	150	-1.82	N(3)	----	N(2)	----	700	-1.15	100	-2.00	20	-2.70	30,000	.48	5,000	-.30	2,000	-1.00	7,000	-.52
73	15	-2.82	70	-2.15	50	-2.30	N(3)	----	N(2)	----	300	-1.52	100	-2.00	N(3)	----	50,000	.70	5,000	-.30	1,000	-1.00	3,000	-.52
76	15	-2.82	70	-2.15	10	-3.00	N(3)	----	N(2)	----	500	-1.30	70	-2.15	10	-3.00	30,000	.48	1,000	-1.00	1,000	-1.00	3,000	-.52
93	30	-2.52	100	-2.00	200	-1.70	N(3)	----	3	-3.52	1,500	-.82	150	-1.82	10	-3.00	100,000	1.00	7,000	-.15	1,500	-.82	5,000	-.30
94	30	-2.52	50	-2.30	200	-1.70	5	-3.30	3	-3.52	300	-1.52	100	-2.00	7	-3.15	30,000	.48	10,000	.00	2,000	-1.00	7,000	-.52
95	20	-2.70	70	-2.15	300	-1.52	5	-3.30	3	-3.52	700	-1.15	100	-2.00	50	-2.30	70,000	.85	7,000	-.15	1,500	-.82	5,000	-.30
96	20	-2.70	50	-2.30	300	-1.52	5	-3.30	3	-3.52	200	-1.70	100	-2.00	30	-2.52	50,000	.70	7,000	-.15	1,500	-.82	5,000	-.30
97	20	-2.70	50	-2.30	150	-1.82	5	-3.30	3	-3.52	300	-1.52	100	-2.00	20	-2.70	70,000	.85	5,000	-.30	1,000	-1.00	3,000	-.52
98	20	-2.70	50	-2.30	100	-2.00	5	-3.30	3	-3.52	700	-1.15	70	-2.15	30	-2.52	20,000	.30	7,000	-.15	10,000	.00	3,000	-.52
99	20	-2.70	50	-2.30	200	-1.70	5	-3.30	3	-3.52	300	-1.52	100	-2.00	20	-2.70	70,000	.85	10,000	.00	700	-1.15	5,000	-.30
100	20	-2.70	30	-2.52	200	-1.70	N(3)	----	3	-3.52	700	-1.15	100	-2.00	20	-2.70	50,000	.70	10,000	.00	1,500	-.82	5,000	-.30
102	20	-2.70	50	-2.30	100	-2.00	N(3)	----	3	-3.52	700	-1.15	100	-2.00	20	-2.70	30,000	.48	5,000	-.30	1,000	-1.00	3,000	-.52
103	2	-3.70	50	-2.30	200	-1.70	N(3)	----	3	-3.52	1,000	-1.00	100	-2.00	15	-2.82	70,000	.85	2,000	-.70	1,500	-.82	3,000	-.52
104	70	-2.15	70	-2.15	100	-2.00	7	-3.15	3	-3.52	1,500	-.82	150	-1.82	20	-2.70	70,000	.85	2,000	-.70	2,000	-1.00	7,000	-.15
105	20	-2.70	50	-2.30	100	-2.00	7	-3.15	3	-3.52	150	-1.82	100	-2.00	20	-2.70	20,000	.30	3,000	-.52	1,000	-1.00	5,000	-.30
106	20	-2.70	70	-2.15	100	-2.00	7	-3.15	3	-3.52	700	-1.15	70	-2.15	3	-3.52	15,000	.18	7,000	-.15	1,500	-.82	5,000	-.30
107	20	-2.70	50	-2.30	100	-2.00	5	-3.30	3	-3.52	300	-1.52	50	-2.30	5	-3.30	10,000	.00	5,000	-.30	1,500	-.82	5,000	-.30
108	20	-2.70	70	-2.15	100	-2.00	5	-3.30	5	-3.30	700	-1.15	50	-2.30	5	-3.30	15,000	.18	3,000	-.52	1,500	-.82	5,000	-.30
109	20	-2.70	70	-2.15	300	-1.52	N(3)	----	10	-3.00	1,000	-1.00	100	-2.00	5	-3.30	70,000	.85	5,000	-.30	1,500	-.82	5,000	-.30
110	20	-2.70	100	-2.00	1,000	-1.00	N(3)	----	15	-2.82	1,000	-1.00	100	-2.00	7	-3.15	70,000	.85	3,000	-.52	1,000	-1.00	3,000	-.52
111	20	-2.70	70	-2.15	500	-1.30	N(3)	----	7	-3.15	700	-1.15	100	-2.00	50	-2.30	50,000	.70	5,000	-.30	1,500	-.82	5,000	-.30
112	20	-2.70	70	-2.15	50	-2.30	N(3)	----	N(2)	----	700	-1.15	70	-2.15	N(3)	----	30,000	.48	2,000	-.70	2,000	-1.00	7,000	-.52
113	15	-2.82	N(30)	----	200	-1.70	N(3)	----	N(2)	----	200	-1.70	70	-2.15	N(3)	----	20,000	.30	5,000	-.30	1,000	-1.00	2,000	-.70
114	20	-2.70	70	-2.15	200	-1.70	N(3)	----	N(2)	----	500	-1.30	70	-2.15	N(3)	----	50,000	.70	3,000	-.52	700	-1.15	2,000	-.70
115	20	-2.70	50	-2.30	100	-2.00	N(3)	----	N(2)	----	300	-1.52	70	-2.15	N(3)	----	30,000	.48	5,000	-.30	700	-1.15	2,000	-.70
122	20	-2.70	70	-2.15	100	-2.00	N(3)	----	N(2)	----	500	-1.30	50	-2.30	N(3)	----	20,000	.30	50	-2.30	500	-1.30	2,000	-.70
123	30	-2.52	100	-2.00	70	-2.15	N(3)	----	N(2)	----	1,000	-1.00	70	-2.15	N(3)	----	20,000	.30	1,000	-1.00	700	-1.15	2,000	-.70
124	20	-2.70	50	-2.30	70	-2.15	20	-2.70	N(2)	----	20	-2.52	70	-2.15	N(3)	----	2,000	.70	5,000	-.30	500	-1.30	3,000	-.52
125	20	-2.70	N(30)	----	100	-2.00	20	-2.70	N(2)	----	30	-2.70	70	-2.15	N(3)	----	3,000	.52	5,000	-.30	700	-1.15	2,000	-.70
126	20	-2.70	N(30																					

TABLE 3.—Analytical data for oxidized silicified and argillized rock samples from the Combination-January cuts—Continued

Sample	Au		Ag		Pb		Bi		Hg		As		Cu		Zn		Mo		Ba		Be		Co	
	ppm	log %	ppm	log %	ppm	log %	ppm	log %	ppm	log %	ppm	log %	ppm	log %	ppm	log %	ppm	log %	ppm	log %	ppm	log %	ppm	log %
Argillized rocks — Continued																								
155	L(0.1)	-----	N(0.1)	-----	5	-3.30	N(5)	-----	0.15	-4.82	10	-3.00	10	-3.00	50	-2.30	3	-3.52	700	-1.15	N(0.3)	-----	N(3)	-----
156	L(0.1)	-----	N(0.1)	-----	5	-3.30	N(5)	-----	20	-4.70	10	-3.00	10	-3.00	50	-2.30	3	-3.52	1,000	-1.00	N(0.3)	-----	N(3)	-3.15
157	1.0	-4.00	N(0.1)	-----	5	-3.30	N(5)	-----	16	-4.80	120	-1.92	7	-3.15	50	-2.30	3	-3.52	2,000	-0.70	1	-4.00	N(3)	-----
158	1.7	-3.78	N(0.1)	-----	5	-3.30	N(5)	-----	40	-4.40	10	-3.00	7	-3.15	60	-2.22	3	-3.52	700	-1.15	1	-4.00	N(3)	-----
159	.18	-4.74	N(0.1)	-----	N(2)	-----	N(5)	-----	44	-4.36	10	-3.00	10	-3.00	25	-2.60	5	-3.30	700	-1.15	1	-4.00	N(3)	-----
160	.40	-4.40	N(0.1)	-----	N(2)	-----	N(5)	-----	52	-4.28	120	-1.92	200	-1.70	30	-2.52	30	-2.52	70	-2.15	1	-4.00	N(3)	-----
164	.90	-4.05	L(1)	-----	50	-2.30	N(5)	-----	28	-4.55	20	-2.70	15	-2.82	L(25)	-----	7	-3.15	2,000	-0.70	1	-4.00	N(3)	-----
165	.60	-4.22	L(1)	-----	15	-2.82	N(5)	-----	24	-4.62	40	-2.40	7	-3.15	L(25)	-----	3	-3.52	300	-1.52	1	-4.00	N(3)	-----
202	6.2	-3.21	N(0.1)	-----	50	-2.30	N(5)	-----	.04	-5.40	60	-2.22	10	-3.00	L(25)	-----	15	-2.82	500	-1.30	1	-4.00	N(3)	-----
203	.36	-4.44	N(0.1)	-----	N(2)	-----	N(5)	-----	.04	-5.40	60	-2.22	50	-2.30	L(25)	-----	5	-3.30	2,000	-0.70	1	-4.00	N(3)	-----
204	.10	-5.00	N(0.1)	-----	N(2)	-----	N(5)	-----	.04	-5.40	L(10)	-----	10	-3.00	L(25)	-----	N(3)	-----	1,000	-1.00	1.5	-3.82	N(3)	-----
205	.46	-4.34	N(0.1)	-----	50	-2.30	N(5)	-----	L(.02)	-----	L(10)	-----	5	-3.30	30	-2.52	N(3)	-----	2,000	-0.70	N(0.3)	-----	N(3)	-----
206	L(0.1)	-----	N(0.1)	-----	3	-3.52	N(5)	-----	.06	-5.22	40	-2.40	30	-2.52	25	-2.60	5	-3.30	1,000	-1.00	1	-4.00	10	-3.00
207	.10	-5.00	N(0.1)	-----	3	-3.52	N(5)	-----	.04	-5.40	10	-3.00	30	-2.52	50	-2.30	3	-3.52	1,000	-1.00	1	-4.00	10	-3.00
208	L(0.1)	-----	N(0.1)	-----	7	-3.15	N(5)	-----	.10	-5.00	10	-3.00	10	-3.00	50	-2.30	3	-3.52	1,000	-1.00	1	-4.00	7	-3.15
209	L(0.1)	-----	N(0.1)	-----	5	-3.30	N(5)	-----	.06	-5.22	10	-3.00	20	-2.70	100	-2.00	5	-3.30	1,000	-1.00	1	-4.00	10	-3.00
210	L(0.1)	-----	N(0.1)	-----	7	-3.15	N(5)	-----	.06	-5.22	L(10)	-----	20	-2.70	40	-2.40	5	-3.30	1,000	-1.00	1.5	-3.82	30	-2.52
211	.30	-4.52	N(0.1)	-----	7	-3.15	N(5)	-----	.06	-5.22	60	-2.22	50	-2.30	50	-2.30	N(3)	-----	1,000	-1.00	1	-4.00	N(3)	-----
212	.10	-5.00	N(0.1)	-----	3	-3.52	N(5)	-----	.08	-5.10	10	-3.00	30	-2.52	110	-1.96	7	-3.15	1,000	-1.00	1.5	-3.82	30	-2.52
213	L(0.1)	-----	N(0.1)	-----	3	-3.52	N(5)	-----	.06	-5.22	10	-3.00	20	-2.70	30	-2.52	5	-3.30	700	-1.15	N(0.3)	-----	N(3)	-----
214	L(0.1)	-----	N(0.1)	-----	30	-2.52	N(5)	-----	.04	-5.40	10	-3.00	30	-2.52	190	-1.72	5	-3.30	1,000	-1.00	1.5	-3.82	7	-3.15
215	L(0.1)	-----	N(0.1)	-----	20	-2.70	N(5)	-----	.06	-5.22	10	-3.00	10	-3.00	50	-2.30	7	-3.15	1,000	-1.00	1.5	-3.82	7	-3.15
216	L(0.1)	-----	N(0.1)	-----	10	-3.00	N(5)	-----	.06	-5.22	10	-3.00	10	-3.00	120	-1.92	N(3)	-----	300	-1.52	1.5	-3.82	10	-3.00
217	L(0.1)	-----	N(0.1)	-----	7	-3.15	N(5)	-----	.04	-5.40	10	-3.00	10	-3.00	110	-1.96	5	-3.30	500	-1.30	1.5	-3.82	N(3)	-----
218	.10	-5.00	N(0.1)	-----	7	-3.15	N(5)	-----	.08	-5.10	20	-2.70	10	-3.00	70	-2.15	3	-3.52	500	-1.30	1	-4.00	N(3)	-----
219	.10	-5.00	N(0.1)	-----	3	-3.52	N(5)	-----	.04	-5.40	10	-3.00	5	-3.30	60	-2.22	N(3)	-----	500	-1.30	1	-4.00	N(3)	-----
224	L(0.1)	-----	N(0.1)	-----	N(2)	-----	N(5)	-----	.06	-5.22	40	-2.40	10	-3.00	L(25)	-----	5	-3.30	200	-1.70	N(0.3)	-----	N(3)	-----
225	.10	-5.00	N(0.1)	-----	3	-3.52	N(5)	-----	.08	-5.10	80	-2.10	20	-2.70	L(25)	-----	7	-3.15	1,500	-0.82	N(0.3)	-----	N(3)	-----
226	L(0.1)	-----	N(0.1)	-----	3	-3.52	N(5)	-----	.06	-5.22	100	-2.00	150	-1.82	L(25)	-----	5	-3.30	1,500	-0.82	N(0.3)	-----	N(3)	-----
227	L(0.1)	-----	N(0.1)	-----	50	-2.30	N(5)	-----	.10	-5.00	120	-1.92	150	-1.82	25	-2.60	5	-3.30	200	-1.70	N(0.3)	-----	N(3)	-----
228	.10	-5.00	N(0.1)	-----	N(2)	-----	N(5)	-----	.04	-5.40	10	-3.00	15	-2.82	50	-2.30	N(3)	-----	7,000	-0.15	10	-3.00	N(3)	-----
229	L(0.1)	-----	N(0.1)	-----	N(2)	-----	N(5)	-----	.04	-5.40	10	-3.00	20	-2.70	60	-2.22	N(3)	-----	1,500	-0.82	1	-4.00	N(3)	-----
230	L(0.1)	-----	N(0.1)	-----	50	-2.30	N(5)	-----	.04	-5.40	100	-2.00	50	-2.30	50	-2.30	3	-3.52	500	-1.30	N(0.3)	-----	N(3)	-----
231	.10	-5.00	1	-4.00	50	-2.30	N(5)	-----	.11	-4.96	60	-2.22	15	-2.82	L(25)	-----	3	-3.52	200	-1.70	N(0.3)	-----	N(3)	-----
232	.16	-4.80	N(0.1)	-----	10	-3.00	N(5)	-----	.06	-5.22	80	-2.10	70	-2.15	L(25)	-----	3	-3.52	700	-1.15	N(0.3)	-----	N(3)	-----
233	.96	-4.02	7	-3.15	N(2)	-----	N(5)	-----	.06	-5.22	10	-3.00	30	-2.52	L(25)	-----	3	-3.52	2,000	-0.70	N(0.3)	-----	N(3)	-----
234	.20	-4.70	N(0.1)	-----	7	-3.15	N(5)	-----	.04	-5.40	10	-3.00	10	-3.00	50	-2.30	3	-3.52	300	-1.52	1.5	-3.82	N(3)	-----
235	L(0.1)	-----	N(0.1)	-----	7	-3.15	N(5)	-----	.04	-5.40	10	-3.00	30	-2.52	L(25)	-----	3	-3.52	200	-1.70	1.5	-3.82	N(3)	-----
236	.10	-5.00	L(1)	-----	5	-3.30	N(5)	-----	.17	-4.77	10	-3.00	100	-2.00	L(25)	-----	5	-3.30	2,000	-0.70	N(0.3)	-----	N(3)	-----
237	L(0.1)	-----	N(0.1)	-----	50	-2.30	N(5)	-----	.06	-5.22	10	-3.00	5	-3.30	L(25)	-----	10	-3.00	300	-1.52	N(0.3)	-----	N(3)	-----
238	L(0.1)	-----	N(0.1)	-----	50	-2.30	N(5)	-----	.10	-5.00	10	-3.00	20	-2.70	L(25)	-----	3	-3.52	1,000	-1.00	1	-4.00	N(3)	-----
239	.26	-4.59	1	-4.00	50	-2.30	N(5)	-----	.10	-5.00	20	-2.70	7	-3.15	L(25)	-----	3	-3.52	300	-1.52	N(0.3)	-----	N(3)	-----
241	3.1	-3.51	L(1)	-----	50	-2.30	N(5)	-----	.10	-5.00	60	-2.22	70	-2.15	L(25)	-----	5	-3.30	1,500	-0.82	N(0.3)	-----	N(3)	-----
242	.28	-4.55	N(0.1)	-----	5	-3.30	N(5)	-----	.20	-4.70	10	-3.00	10	-3.00	L(25)	-----	5	-3.30	300	-1.52	1.5	-3.82	N(3)	-----
243	.78	-4.11	N(0.1)	-----	10	-3.00	N(5)	-----	.10	-5.00	10	-3.00	50	-2.30	L(25)	-----	5	-3.30	1,000	-1.00	N(0.3)	-----	N(3)	-----
244	L(0.1)	-----	N(0.1)	-----	3	-3.52	N(5)	-----	.04	-5.39	10	-3.00	5	-3.30	L(25)	-----	N(3)	-----	300	-1.52	1.5	-3.82	N(3)	-----
245	1.2	-3.93	L(1)	-----	50	-2.30	N(5)	-----	.06	-5.22	60	-2.22	15	-2.82	L(25)	-----	10	-3.00	500	-1.30	N(0.3)	-----	N(3)	-----
247	.10	-5.00	N(0.1)	-----	50	-2.30	N(5)	-----	.10	-5.00	80	-2.10	30	-2.52	L(25)	-----	10	-3.00	700	-1.15	N(0.3)	-----	N(3)	-----
248	.10	-5.00	1	-4.00	100	-2.00	N(5)	-----	.80	-4.10	10	-3.00	50	-2.30	L(25)	-----	7	-3.15	500	-1.30	1.5	-3.82	N(3)	-----
253	.10	-5.00	N(0.1)	-----	7	-3.15	N(5)	-----	.04	-5.40	10	-3.00	15	-2.82	L(25)	-----	N(3)	-----	1,000	-1.00	N(0.3)	-----	N(3)	-----

Sample	Cr		La		Mn		Nb		Ni		Sr		V		Y		Fe		Mg		Ca		Ti	
	ppm	log %	ppm	log %	ppm	log %	ppm	log %	ppm	log %	ppm	log %	ppm	log %	ppm	log %	ppm	log %	ppm	log %	ppm	log %	ppm	log %
Argillized rocks — Continued																								
155	15	-2.82	50	-2.30	70	-2.15	5	-3.30	N(2)	----	500	-1.30	50	-2.30	7	-3.15	15,000	0.18	7,000	-0.15	2,000	-0.70	3,000	-0.52
156	20	-2.70	N(30)	----	70	-2.15	5	-3.30	N(2)	----	200	-1.70	70	-2.15	15	-2.82	15,000	.18	7,000	-.15	10,000	.00	3,000	-.52
157	15	-2.82	N(30)	----	50	-2.30	5	-3.30	N(2)	----	500	-1.30	50	-2.30	N(3)	----	7,000	-.15	5,000	-.30	30,000	.48	3,000	-.52
158	20	-2.70	N(30)	----	200	-1.70	5	-3.30	N(2)	----	300	-1.52	50	-2.30	N(3)	----	10,000	.00	7,000	-.15	2,000	-.70	3,000	-.52
159	20	-2.70	N(30)	----	50	-2.30	N(3)	----	15	-2.82	300	-1.52	100	-2.00	N(3)	----	15,000	.18	7,000	-.15	10,000	.00	2,000	-.70
160	20	-2.70	N(30)	----	150	-1.82	N(3)	----	N(2)	----	700	-1.15	200	-1.70	10	-3.00	G(100,000)	----	1,000	-1.00	700	-1.15	1,000	-1.00
164	20	-2.70	N(30)	----	150	-1.82	7	-3.15	N(2)	----	700	-1.15	70	-2.15	20	-2.70	30,000	.48	2,000	-.70	1,500	-.82	2,000	-.70
165	20	-2.70	70	-2.15	30	-2.52	7	-3.15	N(2)	----	300	-1.52	70	-2.15	20	-2.70	15,000	.18	5,000	-.30	1,000	-1.00	3,000	-.52
202	30	-2.52	70	-2.15	50	-2.30	N(3)	----	N(2)	----	500	-1.30	50	-2.30	N(3)	----	70,000	.85	70,000	.85	1,500	-.82	3,000	-.52
203	20	-2.70	N(30)	----	100	-2.00	N(3)	----	N(2)	----	200	-1.70	70	-2.15	N(3)	----	30,000	.48	7,000	-.15	1,500	-.82	3,000	-.52
204	20	-2.70	N(30)	----	70	-2.15	N(3)	----	N(2)	----	300	-1.52	50	-2.30	N(3)	----	5,000	-.30	7,000	-.15	1,500	-.82	3,000	-.52
205	30	-2.52	50	-2.30	50	-2.30	3	-3.52	N(2)	----	700	-1.15	70	-2.15	N(3)	----	3,000	-.52	7,000	-.15	5,000	-.30	3,000	-.52
206	20	-2.70	50	-2.30	1,000	-1.00	N(3)	----	L(30)	----	500	-1.30	70	-2.15	15	-2.82	20,000	.30	3,000	-.52	3,000	-.52	3,000	-.52
207	20	-2.70	50	-2.30	500	-1.30	7	-3.15	L(30)	----	700	-1.15	70	-2.15	15	-2.82	30,000	.48	5,000	-.30	5,000	-.30	3,000	-.52
208	15	-2.82	50	-2.30	2,000	-0.70	5	-3.30	N(2)	----	500	-1.30	70	-2.15	15	-2.82	7,000	-.15	5,000	-.30	2,000	-.70	3,000	-.52
209	30	-2.52	50	-2.30	700	-1.15	5	-3.30	N(2)	----	700	-1.15	70	-2.15	10	-3.00	20,000	.30	7,000	-.15	2,000	-.70	3,000	-.52
210	20	-2.70	70	-2.15	700	-1.15	5	-3.30	L(3)	----	700	-1.15	70	-2.15	50	-2.30	30,000	.48	7,000	-.15	5,000	-.30	3,000	-.52
211	20	-2.70	70	-2.15	100	-2.00	7	-3.15	N(2)	----	700	-1.15	70	-2.15	20	-2.70	20,000	.30	7,000	-.15	5,000	-.30	3,000	-.52
212	20	-2.70	70	-2.15	3,000	-0.52	N(3)	----	L(30)	----	500	-1.30	70	-2.15	15	-2.82	50,000	.70	2,000	-.70	5,000	-.30	3,000	-.52
213	20	-2.70	50	-2.30	50	-2.30	N(3)	----	N(2)	----	300	-1.52	70	-2.15	10	-3.00	30,000	.48	5,000	-.30	2,000	-.70	3,000	-.52
214	30	-2.52	70	-2.15	100	-2.00	5	-3.30	N(2)	----	1,500	-.82	70	-2.15	10	-3.00	30,000	.48	7,000	-.15	5,000	-.30	3,000	-.52
215	20	-2.70	70	-2.15	100	-2.00	5	-3.30	N(2)	----	500	-1.30	70	-2.15	10	-3.00	20,000	.30	5,000	-.30	3,000	-.52	3,000	-.52
216	20	-2.70	50	-2.30	150	-1.82	N(3)	----	N(2)	----	300	-1.52	70	-2.15	10	-3.00	50,000	.70	7,000	-.15	3,000	-.52	3,000	-.52
217	20	-2.70	70	-2.15	50	-2.30	N(3)	----	N(2)	----	500	-1.30	70	-2.15	20	-2.70	30,000	.48	5,000	-.30	3,000	-.52	3,000	-.52
218	30	-2.52	50	-2.30	70	-2.15	3	-3.52	N(2)	----	500	-1.30	70	-2.15	15	-2.82	20,000	.30	5,000	-.30	3,000	-.52	2,000	-.70
219	70	-2.15	50	-2.30	100	-2.00	N(3)	----	N(2)	----	500	-1.30	150	-1.82	30	-2.52	30,000	.48	7,000	-.15	3,000	-.52	3,000	-.52
224	30	-2.52	N(30)	----	150	-1.82	5	-3.30	N(2)	----	70	-2.15	70	-2.15	N(3)	----	20,000	.30	7,000	-.15	300	-1.52	3,000	-.52
225	50	-2.30	300	-1.52	100	-2.00	N(3)	----	N(2)	----	1,000	-1.00	100	-2.00	100	-2.00	100,000	1.00	5,000	-.30	500	-1.30	2,000	-.70
226	30	-2.52	70	-2.15	50	-2.30	N(3)	----	N(2)	----	200	-1.70	70	-2.15	10	-3.00	50,000	.70	30	-2.52	700	-1.15	3,000	-.52
227	30	-2.52	50	-2.30	10	-3.00	N(3)	----	N(2)	----	700	-1.15	50	-2.30	N(3)	----	50,000	.70	7	-3.15	700	-1.15	2,000	-.70
228	30	-2.52	50	-2.30	70	-2.15	10	-3.00	N(2)	----	300	-1.52	70	-2.15	10	-3.00	3,000	-.52	3,000	-.52	300	-1.52	3,000	-.52
229	30	-2.52	50	-2.30	70	-2.15	10	-3.00	N(2)	----	150	-1.82	70	-2.15	30	-2.52	15,000	.18	7,000	-.15	300	-1.52	3,000	-.52
230	50	-2.30	70	-2.15	30	-2.52	N(3)	----	N(2)	----	700	-1.15	100	-2.00	10	-3.00	30,000	.48	2,000	-.70	500	-1.30	3,000	-.52
231	30	-2.52	70	-2.15	50	-2.30	N(3)	----	N(2)	----	1,000	-1.00	100	-2.00	15	-2.82	30,000	.48	3,000	-.52	700	-1.15	3,000	-.52
232	30	-2.52	50	-2.30	30	-2.52	N(3)	----	N(2)	----	1,500	-.82	70	-2.15	N(3)	----	30,000	.48	150	-1.82	700	-1.15	2,000	-.70
233	30	-2.52	N(30)	----	150	-1.82	7	-3.15	N(2)	----	500	-1.30	100	-2.00	10	-3.00	30,000	.48	7,000	-.15	700	-1.15	3,000	-.52
234	30	-2.52	70	-2.15	100	-2.00	7	-3.15	N(2)	----	700	-1.15	100	-2.00	20	-2.70	5,000	-.30	5,000	-.30	5,000	-.30	3,000	-.52
235	30	-2.52	70	-2.15	70	-2.15	7	-3.15	N(2)	----	500	-1.30	70	-2.15	20	-2.70	5,000	-.30	5,000	-.30	3,000	-.52	3,000	-.52
236	20	-2.70	50	-2.30	150	-1.82	7	-3.15	N(2)	----	50	-2.30	70	-2.15	N(3)	----	50,000	.70	5,000	-.30	300	-1.52	3,000	-.52
237	30	-2.52	70	-2.15	150	-1.82	N(3)	----	N(2)	----	2,000	-.70	100	-2.00	15	-2.82	G(100,000)	----	7,000	-.15	1,000	-1.00	2,000	-.70
238	30	-2.52	50	-2.30	150	-1.82	7	-3.15	N(2)	----	70	-2.15	70	-2.15	N(3)	----	3,000	-.52	5,000	-.30	300	-1.52	3,000	-.52
239	30	-2.52	N(30)	----	150	-1.82	7	-3.15	N(2)	----	300	-1.52	100	-2.00	N(3)	----	20,000	.30	7,000	-.15	10,000	.00	3,000	-.52
241	30	-2.52	100	-2.00	70	-2.15	N(3)	----	N(2)	----	1,500	-.82	100	-2.00	15	-2.82	70,000	.85	5,000	-.30	1,000	-1.00	3,000	-.52
242	30	-2.52	50	-2.30	100	-2.00	10	-3.00	N(2)	----	300	-1.52	70	-2.15	10	-3.00	20,000	.30	7,000	-.15	300	-1.52	3,000	-.52
243	30	-2.52	50	-2.30	100	-2.00	N(3)	----	N(2)	----	1,000	-1.00	70	-2.15	10	-3.00	30,000	.48	5,000	-.30	700	-1.15	2,000	-.70
244	30	-2.52	50	-2.30	50	-2.30	10	-3.00	N(2)	----	300	-1.52	70	-2.15	N(3)	----	700	-.70	3,000	-.52	700	-1.15	2,000	-.70
245	50	-2.30	100	-2.00	70	-2.15	N(3)	----	N(2)	----	2,000	-.70	70	-2.15	10	-3.00	G(100,000)	----	1,000	-1.00	700	-1.15	2,000	-.70
247	30	-2.52	100	-2.00	50	-2.30	N(3)	----	N(2)	----	1,500	-.82	100	-2.00	N(3)	----	G(100,000)	----	5,000	-.30	700	-1.15	2,000	-.70
248	30	-2.52	50	-2.30	100	-2.00	7	-3.15	N(2)	----	1,000	-1.00	70	-2.15	10	-3.00	15,000	.18	7,000	-.15	3,000	-.52	3,000	-.52
253	30	-2.52	N(30)	----	50	-2.30	5	-3.15	N(2)	----	700	-1.15	70	-2.15	N(3)	----	20,000	.30	3,000	-.52	700	-1.15	3,000	-.52

DISTRIBUTION OF GOLD AND OTHER ORE-RELATED ELEMENTS NEAR ORE BODIES, GOLDFIELD, NEVADA

TABLE 4.—Statistical data for oxidized silicified and argillized rock samples from the Combination-January cuts
[—, not calculated]

Element	Detection limit log percent (ppm)	Percent samples outside detection limit	Logarithmic mean, log percent	Logarithmic standard deviation, log percent	Cohen's mean, log percent	Cohen's standard deviation, log percent	Geometric mean, ppm or percent (noted)	Geometric deviation	Sichels' ^t ppm or percent (noted)
129 silicified rock samples									
Au	-5.00(0.1)	0.8	-3.9	0.6	-3.9	0.6	1.3	3.8	3.2
Ag	¹² -5.08(0.1)	35	-3.5	.4	-4.3	1.2	0.5	16	20
Pb	-3.75(2)	.8	-1.7	.4	-1.7	.5	200	3.1	300
Bi	-3.42(5)	65	-----	-----	-----	-----	-----	-----	-----
Hg	-----	0	-4.9	.3	-----	-----	0.14	2.0	0.18
As	-3.00(10)	7.0	-2.5	.5	-2.5	.5	30	3.3	60
Cu	-----	0	-2.8	.4	-----	-----	15	2.6	30
Zn	-2.60(25)	72	-----	-----	-----	-----	-----	-----	-----
Mo	-3.58(3)	54	-----	-----	-----	-----	-----	-----	-----
Ba	-----	0	-1.2	.2	-----	-----	700	1.6	700
Be	-4.58(0.3)	88	-----	-----	-----	-----	-----	-----	-----
Co	-3.58(3)	95	-----	-----	-----	-----	-----	-----	-----
Cr	-3.75(2)	2.3	-2.8	.2	-2.8	.3	15	1.8	20
La	-2.58(30)	64	-----	-----	-----	-----	-----	-----	-----
Mn	-4.08(1)	.8	-2.8	.6	-2.8	.7	15	4.5	50
Nb	-3.58(3)	67	-----	-----	-----	-----	-----	-----	-----
Ni	-3.75(2)	91	-----	-----	-----	-----	-----	-----	-----
Sr	-----	0	-1.3	.3	-----	-----	500	2.1	700
V	-----	0	-2.2	.2	-----	-----	70	1.5	70
Y	-3.58(3)	82	-----	-----	-----	-----	-----	-----	-----
Fe	1.08(10%)	³ 1.6	0.0	.5	0.0	.5	1%	3.4	2%
Mg	-4.08(1)	7.0	-1.9	.5	-2.1	.7	70	5.4	300
Ca	-----	0	-1.2	.3	-----	-----	700	2.0	900
Ti	-----	0	-0.6	.1	-----	-----	2000	1.4	2000
149 argillized rock samples									
Au	-5.00(0.1)	40	-4.6	.4	-5.0	0.5	0.11	3.5	0.25
Ag	¹² -5.08(0.1)	58	-----	-----	-----	-----	-----	-----	-----
Pb	-3.75(2)	11	-2.8	.5	-2.9	.6	10	4.0	30
Bi	-3.42(5)	98.7	-----	-----	-----	-----	-----	-----	-----
Hg	-----	1.3	-5.1	.3	-5.1	.3	0.09	2.0	0.11
As	-3.00(10)	13	-2.7	.4	-3.0	.5	10	2.8	20
Cu	-----	0	-2.8	.4	-----	-----	15	2.3	20
Zn	-2.60(25)	47	-2.3	.2	-2.6	.4	25	2.4	40
Mo	-3.58(3)	26	-3.3	.2	-3.4	.3	3	2.1	5
Ba	-----	0	-1.1	.3	-----	-----	700	2.1	1000
Be	-4.58(0.3)	32	-4.0	.3	-4.3	.5	0.5	3.0	1.0
Co	-3.58(3)	60	-----	-----	-----	-----	-----	-----	-----
Cr	-----	0	-2.7	.2	-----	-----	20	1.5	20
La	-2.58(30)	15	-2.2	.1	-2.3	.2	50	1.7	60
Mn	-----	0	-2.0	.5	-----	-----	100	2.9	200
Nb	-3.58(3)	47	-3.2	.2	-3.5	.4	3	2.3	4
Ni	-3.75(2)	65	-----	-----	-----	-----	-----	-----	-----
Sr	-----	0	-1.3	.4	-----	-----	500	2.3	700
V	-----	0	-2.1	.1	-----	-----	70	1.3	80
Y	-3.58(3)	22	-2.9	.3	-3.1	.5	7	2.9	10
Fe	1.08(10%)	³ 3.4	0.3	.4	.4	.4	2%	2.6	4%
Mg	-----	0	-.4	.5	-----	-----	3000	3.0	7000
Ca	-----	0	-.9	.4	-----	-----	1500	2.4	2000
Ti	-----	0	.5	.1	-----	-----	3000	1.4	3000

¹Ppm figure is near the midpoint of a range of concentrations equal to $\sqrt[10]{10}$. The log percent figure is the lower boundary for the same range. Applies to Ag, Pb, Bi, Mo, Be, Co, Cr, La, Mn, Nb, Ni, Y, Fe, and Mg, obtained by 6-step semiquantitative spectrographic analysis.

²For Ag, some determinations reported as less than 1ppm (-4.08 log percent).
³Represents percentage of samples above upper detection limit. For all other elements, represents percentage of samples below lower detection limit.

portion from a crushed, ground, and mixed sample is part of the combined sampling and analytical variance discussed in the preceding paragraph. The extent to which this type of sampling error contributes to variations in gold values can be assessed knowing the maximum size of gold in the rocks sampled and the size of analytical portion used for analysis. Gold for atomic absorption analysis was extracted from only 2 grams of sample, an analytical portion very much smaller than

the field sample, which was 2-3 kg. Gold was separated from approximately ½-kilogram portions of the three samples having the highest gold values: the largest gold particle recovered was a thick flake 0.07 mm in diameter (W. J. Keith, unpub. data). The diagram prepared by Clifton, Hunter, Swanson, and Phillips (1969, p. C8) relating gold particle mass (and particle diameter, for both spheres and flakes) to size of analytical portion expected to contain 20 gold particles for samples of various true

grades¹³ shows that sampling error is acceptable for 0.07-mm flakes only if the true grade is larger than about 10 ppm. Gold flakes not twice as large (0.125 mm) or gold spheres of about the same diameter (0.062 mm) would produce sampling error for rocks having a true grade less than about 30 ppm, which is nearly the same as the highest reading (29 ppm) obtained in this study. Most of the gold is probably smaller than 0.07 mm, and most 2-g analytical portions probably contain more than 20 particles of gold, but it is likely that a relatively small number of relatively large gold particles significantly affect the readings for some samples. The replicate samples described above and unaltered dacite, unoxidized silicified dacite, and unoxidized average-grade ore samples were analysed using a 10-g analytical portion. With an analytical portion of this size, 0.062-mm gold spheres (or 0.125-mm gold flakes) would produce sampling error at true grades below about 6 ppm, and 0.062-mm gold flakes would produce sampling error only at true grades below about 0.8 ppm. We expect, then, that in silicified rocks with enough gold to be of economic interest, sampling error resulting from removal of an analytical portion from a crushed, ground, and mixed sample should be a minor problem when using 10-g or larger analytical portions.

Any sampling program meant to determine grades and tonnages of the low-tenor silicified rocks in the Combination-January area must be designed with care. Gold analyses by atomic absorption probably should be done using 10-g analytical portions. Fire assay, utilizing 29.167 g of sample, would also be appropriate. Since the main objective of this report is to delineate indicator elements for gold, some error related to field sampling and removal of analytical portions is not objectionable, but for a more precise determination of ore grade, more careful field sampling and analysis are necessary. The replicate sample results indicate, however, that in this study we cannot attach great significance to the exact gold value determined for any given sample.

Keeping these limitations in mind, the grade of unmined silicified rock exposed in the cuts can be estimated using the data at hand. The geometric means calculated for various elements in the several data sets discussed in this report are suitable for comparison with one another, but Sichel's *t* provides a better estimate of true abundance than the geometric mean (see section on "Statistical Methods.") For the silicified rocks of the cuts, *t* is 3 ppm. With 95-percent confidence, the true abundance should be between about 2 and 4 ppm (confidence interval calculated by method of Aitchison and Brown, 1963, p. 50). One part per million gold is

equivalent to 0.0291667 ounce troy per short ton; specifically, 3 ppm is equivalent to 0.088 ounce per ton. These amounts of gold are large enough to commend further exploration and evaluation of the remaining vein material.

LEAD

Oxidized silicified rock samples show many high lead values (200 ppm or more) and intermediate lead values (70–150 ppm), whereas oxidized argillized rock samples show only 5 high values and 10 intermediate values (pl. 3). Some of the intermediate values in argillized rocks are adjacent to silicified zones, as at locality 10 and near localities 13 and 19. An intermediate value appears in a shear zone adjacent to silicified rock at locality 12, and a high value appears in a fault zone adjacent to silicified rock at locality 6. Four of the five high values for argillized rocks are grouped together north of locality 6. This group of relatively high-lead samples is not associated with any distinctive structural or alteration feature.

The anomaly contrast shown by the profile is representative of that expected along any traverse across the strike of the silicified zones in the vicinity of the cuts. The anomaly contrast is as strong as that for gold itself, and in some profiles it may well be stronger.

Consistently high lead values appear within the silicified zones in the areas characterized by high gold values. Between localities 7 and 10, scattered high lead values accompany intermediate gold values. Other smaller silicified outcrops all show some degree of consistency between gold and lead values, but it is difficult to predict gold tenor from lead readings. The histogram for silicified rocks (pl. 3) shows large frequencies in four class intervals above the logarithmic mean: 200, 300, 500, and 700 ppm, so that the frequency distribution looks skewed toward the higher values, with a very small upper tail above 700 ppm. The frequency distribution for gold, by comparison, shows a long, rather smoothly declining upper tail above the logarithmic mean. Thus even though an area may show some very high gold values, along with some high and intermediate values, almost all the lead readings are between 200 and 700 ppm. Lead values from oxidized silicified rocks therefore give no indication of the highest gold values to be anticipated, but lead values of 200 ppm or larger indicate that gold values of at least 1 ppm will be found nearby (loc. 16 is an exception). A different method of chemical analysis offering greater analytical precision for rocks with true lead values between 100 and 1,000 ppm might improve the correlation between gold and lead for individual samples, but geologic factors, rather than analytical precision, may account for the limited range of variation for lead in relatively gold-rich samples (see p. 36). The apparent ceiling on lead

¹³If a sample contains 20 particles of gold, it is 95 percent probable that the true gold value will be within a range of values from approximately 50 percent more to approximately 50 percent less than the value obtained by chemical analysis (Clifton and others, 1969).

values has an advantage for geochemical exploration, in that lead might well show broader, less ragged anomalies over potential gold ore bodies than would gold itself.

SILVER

All high silver values (greater than or equal to 10 ppm) appear in silicified rocks (pl. 3). All but one intermediate value (3–7 ppm) are also in silicified rocks; the single exception appears at locality 17 in argillized rocks associated with a fault zone. Of the eight low values (between 1 and 2 ppm) in argillized rocks, three are adjacent to silicified zones (loc. 12, 13, and 19), and one is in a fault zone (southeast of loc. 17). Almost all the oxidized argillized samples and 48 of the oxidized silicified rock samples (37 percent) bear less than 1 ppm silver. Obviously, no notable silver halo exists in argillized rocks. The geochemical profile shows an anomaly contrast typical of that expected at many places in the cuts. Profiles run northeast of the January shaft, however, might show anomalies much stronger than those shown on profile A–A'. The gold and silver patterns in the silicified zones are grossly similar, even though larger areas within the zones show relatively low silver values.

The semiquantitative spectrographic data available for silver are not precise enough to allow a good determination of silver tenor in the oxidized silicified rocks. Even an approximate estimate is not possible because the detection threshold for 26 of the silicified rock samples (20 percent) was 1 ppm, owing to spectral interference, rather than the usual 0.1 ppm. In calculating the geometric mean for the silicified rocks by Cohen's method, the lower of these two detection limits, 0.1 ppm, was used, possibly biasing the result toward low values. Furthermore, the histogram for silver in silicified rocks is very irregular; the frequency distribution may be polymodal, although more data are required to determine the character of this distribution. The logarithmic standard deviation shown with the histogram (pl. 3) is so large that the associated logarithmic mean has little meaning. The data suggest, however, that fire assays of samples taken northeast of the January shaft should show some silver values as high as 1 ounce troy per short ton.

BISMUTH

Only two oxidized argillized rock samples yielded detectable amounts of bismuth (5 ppm). Readings from 45 oxidized silicified samples range from 5 to 200 ppm, but most of the silicified samples (65 percent) have less than 5 ppm bismuth. Clearly, the 5-ppm detection threshold provided by the semiquantitative spectrographic technique is too high to provide enough data for many conclusions about geochemical relations. Bis-

muth cannot be fully evaluated as an indicator element for gold, but it obviously shows a strong preference for silicified zones, and most of the intermediate and high bismuth values appear northeast of the January mine shaft, in an area characterized by intermediate and high gold values (pl. 3).

Only three readings above the detection threshold appear along the geochemical profile line, so the profile for bismuth is not included with plate 3.

MERCURY

The oxidized silicified rocks of the cuts contain more mercury than do the oxidized argillized rocks. The logarithmic means for the two data sets are not greatly different (see histograms on pl. 3), but they are significant statistically at the 99-percent-confidence level. Silicified rocks along the south and west sides of the largest cut that continue into the area northeast of the January shaft have many intermediate (0.11–0.30 ppm) and high (greater than 0.30 ppm) mercury values (pl. 3). Throughout the southeast cut (loc. 16 to loc. 20), silicified and argillized rocks are similar. The silicified rock east of locality 19 has intermediate to high gold values, but it is expressed no more distinctly on the mercury map than is locality 16. In contrast, the area northeast of the January shaft with high gold values certainly has the most mercury.

The consistently intermediate to high mercury values south of locality 4 and between localities 3 and 4 suggest that mercury halos may extend 30–35 feet into argillized rocks from silicified zone contacts in gold-bearing areas. The width of this possible halo, however, is small relative to the width of the adjacent silicified zone, about 90 feet at locality 4. Also, the geochemical profile reveals that the anomaly contrast is very low. The histograms jointly show that the total range of mercury values is barely two orders of magnitude, compared with at least three, and probably four, orders of magnitude for gold, so mercury anomalies are not likely to be very strong. Under these circumstances, relatively narrow halos extending into argillized rocks are not particularly valuable for reconnaissance sampling; they might be of minor value for a detailed sampling program in a small area.

ARSENIC

The Gutzeit colorimetric method used for arsenic determination has a reporting interval that becomes larger with increasing values but is arithmetic within certain ranges of values; some problems result when the data are subdivided into ranges of values for the histogram and for the geochemical map. Values reported for the oxidized rocks of plate 4 are less than 10, 10, 20, 40, 60, 80, 100, 120, 140, 160, 180, 200, and 250 ppm. Corresponding log percent figures are less than –3.00,

-3.00, -2.70, -2.40, -2.22, -2.10, -2.00, -1.92, -1.85, -1.80, -1.74, -1.70, and -1.60. Within this range of values, the interval is arithmetic except for the upper and lower ends of the range. The histograms (pl. 4) are based on the logarithms of the reported values, however, to avoid overemphasizing values of 200 ppm or more and to make the histograms more comparable with those on the other plates. The resulting histograms, with class intervals determined by Sturges' rule, have null class intervals below $-2.50 \log$ percent. Other class intervals, determined arbitrarily, do not eliminate the problem unless the number of class intervals is reduced to three or four, which in turn eliminates variations shown in the upper parts of the histograms. Such treatment also obscures the fact that a disproportionate number of values for both silicified and argillized rocks were read as 10 ppm; 10 ppm was reported for 49 of the 129 silicified rocks (38 percent) and 74 of the 149 argillized rocks (49.7 percent), whereas less than 10 ppm was reported for only 7.0 percent of the silicified rocks and 12.8 percent of the argillized rocks. Analytical discrimination was apparently poor near the detection threshold for the Gutzeit colorimetric test. Readings of less than 10 ppm and 10 ppm are therefore given the same symbol on plate 4.

The geometric means indicate that oxidized silicified rocks have about three times as much arsenic, overall, as do oxidized argillized rocks. However, since the problems with reporting interval and analytical discrimination produce discontinuities among the smaller data values, as shown by the histograms, the validity of these geometric means is questionable. The percentages of samples read as less than 10, 10, 20, and 40 ppm, however, are generally similar for the two data sets, so improved analyses would likely have similar effects on both frequency distributions and geometric means. The upper parts of the two frequency distributions, clearly different, probably would not be substantially changed. Both geometric means would likely be decreased with better analyses, but the difference between them would probably not be changed much.

For geochemical exploration, arsenic is not reliable as an indicator for gold. Although oxidized silicified rocks contain more arsenic than oxidized argillized rocks, as is true for the preceding elements, the relation between arsenic and gold is not consistent (compare pl. 3 with pl. 4). Intermediate (60-80 ppm) and high (100 ppm or more) arsenic values accompany moderate to high gold values for most, but by no means all, samples northeast of the January shaft. Arsenic values are relatively lower than gold values for the area between localities 6 and 7, relatively higher than gold values for the area between localities 8 and 10, relatively lower in the vicinity of locality 12, and relatively higher at locality 16.

The other silicified rock outcrops show a few samples with concordant gold and arsenic values, but these are only a small percentage of the silicified rock samples.

Intermediate and high arsenic values appear at many localities in oxidized argillized rocks. Some are associated with fault zones and shear zones, but many are not. Halos around silicified zones do not exist. The geochemical profile shown is typical for argillized rock areas, but gold-bearing silicified rocks could show greater arsenic anomaly contrast in profiles taken at other locations. With the small range of variation in the data, however, even a profile taken in the northwestern part of the cuts would show only modest anomaly contrast.

COPPER

The distribution of copper and gold (pls. 3 and 4) is dissimilar except in the vicinity of locality 1 where there are samples containing relatively large amounts of both copper and gold. The histograms for oxidized silicified rocks and argillized rocks are very similar, and the two data sets have nearly the same range of values. The logarithmic means and deviations are not significantly different statistically at the 95-percent-confidence level. Throughout the map area, fault zones and shear zones are not particularly favorable to high copper values relative to less broken ground.

Obviously, copper cannot be used as an indicator element for gold in oxidized silicified rocks (pl. 4). Some areas of argillized rock with intermediate and high copper values, such as those between localities 10 and 12 and between localities 16 and 17, may or may not represent a halo. One or more longer profiles across strike would be helpful in answering this question, but the low values between localities 3 and 4 and the lack of a systematic decrease in values from locality 12 to locality 11 indicate that a halo is not consistently developed.

MOLYBDENUM

Most silicified outcrops show only a few scattered intermediate and high molybdenum values with no consistent relation to gold values. Some intermediate (7-10 ppm) and high (15 ppm or more) molybdenum values are scattered throughout the high-gold area northeast of the January shaft (pl. 4). The overall tenor of molybdenum is higher in oxidized argillized rocks than it is in oxidized silicified rocks. The intermediate and high molybdenum values in argillized rocks are also scattered, but about half of these values are associated with faults and shear zones (west of loc. 2, at loc. 5, near loc. 6, north of loc. 13, near loc. 14, and south of loc. 16). No coherent halo is developed in argillized rocks. The geochemical profile demonstrates that molybdenum values cannot be predicted on the basis of alteration and structural criteria.

ZINC

Except for a few scattered intermediate (50–90 ppm) and high (100 ppm or more) values, zinc is relatively scarce in the oxidized silicified rocks (pl. 4). Intermediate zinc values appear near silicified zones between localities 10 and 11, 16 and 17, and at locality 3; this pattern suggests that zinc may form a geochemical halo. As is true for copper, however, other areas near gold-bearing silicified rocks, particularly between localities 11 and 12 and between localities 3 and 4, are not enriched in zinc, so a halo is not consistently developed. The group of intermediate and high values found along the cut wall east of locality 14 and 100 feet northeast of locality 13 shows no systematic relation to faults or shear zones.

The geochemical profile for zinc is not particularly informative, so it is not included with plate 4.

INTERPRETATION OF THE GEOCHEMICAL MAPS: SEPARATING EFFECTS OF HYPOGENE AND SUPERGENE PROCESSES

The distribution of gold and other ore-related metals in the Combination-January cuts is the result of two processes: hydrothermal alteration culminating in metallization, and oxidation. Here metallization is a primary (and epigenetic) geochemical dispersion process, and oxidation and accompanying dissolution and redeposition of the epigenetic elements constitute a secondary geochemical dispersion process. This section investigates the degree to which the map pattern for each element is the result of secondary rather than primary dispersion processes.

MOBILITY OF ELEMENTS IN THE ZONE OF OXIDATION

Because the hydrothermally altered rocks at Goldfield, both silicified and argillized, have ubiquitous pyrite (Ransome, 1909, p. 113–114; and our observations), strong supergene alteration is possible. In the prevailing arid climate, surface water descends to the water table, reacting with pyrite above the water table to yield Fe^{2+} , Fe^{3+} , HSO_4^- , and SO_4^{-2} . Most of the iron usually reacts further to form limonite minerals (goethite, $\text{FeO}(\text{OH})$, and hematite, Fe_2O_3). Where ore is exposed to meteoric waters, other sulfides and sulfosalts are also oxidized to yield metal cations and sulfate ion (SO_4^{-2}). Studies on mine waters (Baas Becking and others, 1960; Sato, 1960) and on experimental oxidation of iron and manganese (Sato, 1960) indicate that Eh values in oxidizing sulfide ore deposits may be as high as +0.6–+0.86 volt with low accompanying pH values of 2–3. Any metal whose compounds (hydroxide, carbonate, chloride, and particularly sulfate) are soluble¹⁴ in these

¹⁴Garrels and Christ (1965) consider a species with an activity of 10^{-6} molal or greater soluble in the framework of geologic processes.

relatively high-Eh and low-pH aqueous solutions will be mobile in this environment. Highly mobile (soluble) elements, such as copper, may be thoroughly leached, destroying their primary dispersion patterns. Metals having intermediate mobility, such as molybdenum, are transported only short distances and precipitated, some along with limonite. Some metal cations are easily reduced to the native metal and precipitated (mercury) or form stable compounds that remain close to or at the sites of their primary minerals (lead). The latter elements should reveal relict primary dispersion patterns. Copper, and silver to a lesser extent, may be redeposited below the water table to form a supergene enrichment zone. The samples from the cuts at Goldfield, however, lie approximately in a plane parallel to the ground surface and within the upper part of the oxidized zone, so supergene enrichment effects can be ruled out. Ransome (1909, p. 170–174), in describing Goldfield oxidized ores and changes in the ores with depth, does not mention supergene enrichment at or near the water table, but we have found indications that supergene enrichment occurs at least locally (see p. 42). Leaching effects should be nearly the same in rocks of the cuts as at the ground surface.

Several authors give relative mobilities for many of the metals considered here. Table 5 summarizes information given by three authors, who have in turn assembled data from other sources. Zinc is likely to be highly mobile, copper and molybdenum moderately to highly mobile, silver and gold moderately mobile, arsenic immobile to moderately mobile, and lead, bismuth, antimony, and tellurium immobile. Krauskopf (1967)

TABLE 5.—Relative mobilities of various metals in the supergene environment

Mobility		Krauskopf (1967)	Hawkes and Webb (1962)	Andrews-Jones (1968) ¹	
				Oxidizing	Acid
High	Very high	Zn	Cu	--	--
	High	Cu	Zn Mo	Mo Zn	Mo Zn Cu, Hg, Ag Au
Medium		Ag	Mo	Cu, Hg, Ag, Au	As
		Au ²	Au(?) Fe	As	
Low	Low	Au ² Pb Hg Fe Mn	Pb As Hg Bi(?) Ag(?) Fe Mn	Pb Bi Sb	Pb, Bi, Sb Fe, Mn
	Very low			Fe, Mn Te	Te

¹Taken from table 1 of Andrews-Jones, data from Perel'man (1967), Hawkes and Webb (1962), and Ginzburg (1960). Environmental conditions categorized on table 1 of Andrews-Jones include oxidizing, acid, neutral to alkaline, and reducing. Both oxidizing and acid conditions appear to apply to oxidizing sulfide ore deposits in a desert area.

²Krauskopf (1967, p. 525) concludes on the basis of laboratory data and thermodynamic calculations that "*** appreciable transportation of gold should be a rare and local phenomenon." (See also Cloke and Kelly, 1964.)

and Hawkes and Webb (1962) agree that mercury should show low mobility in solution, but Hawkes and Webb indicate that it may be very mobile in the vapor phase.

During oxidation, ground water passing through rocks bearing pyrite and other sulfide minerals dissolves and carries away mobile elements. Where such ground water meets mine workings, it evaporates, leaving coatings and crusts of hydrated sulfates that incorporate the metals actively being leached (see for example Lovering, in Morris and Lovering, 1952). Such coatings are common on the walls of mine workings beneath oxidizing sulfide ore bodies, and hydrated iron sulfates are usually the most abundant constituents of the coatings; these hydrated iron sulfates, formed from iron released by the oxidation of pyrite, are intermediate products that are eventually converted to hematite and goethite (Blanchard, 1968, p. 51-55).

Eight samples of secondary hydrated sulfates from walls of workings in the Florence mine (table 6 and fig. 3) contain relatively large amounts of copper and zinc, lesser but notable amounts of bismuth and molybdenum, and cobalt, nickel, and manganese as well. None of the seven hydrated iron sulfate samples contain as much as 1 ppm silver, but the gypsum sample contains 3 ppm silver. None of the samples has as much as 7 ppm lead. The detection thresholds for gold (15 ppm), arsenic (200 ppm), antimony (100 ppm), and tellurium (1,000 ppm) are too high to allow significant amounts to be recognized, except for antimony in gypsum (700 ppm). All the sulfates sampled except gypsum are readily soluble in water, so they were separated and cleaned by hand picking; consequently, insufficient material was available for extensive chemical testing.

The workings in the Florence mine generally follow a north-trending silicified zone that forms the southern extension of the Combination vein system, as previously mentioned. The silicified zone and ore shoots within it dip steeply, and the Florence shaft passes close

to the silicified zone from the surface all the way down to the 350-foot (7th) level. Silicified rock is oxidized to the 100-foot (2d) level, but little oxidation appears on the 150-foot (3d) level and none below it (Ransome, 1909, p. 227). A small flow of water has entered the 350-foot level since at least 1908 (Ransome, 1909, p. 230). Samples F-350-3A and F-350-4A, B are crusts from the only part of the mine that was wet at the time of sampling. The sulfates at localities F-350-8 and F-350-9 form incrustations also; this part of the mine was probably wet at some time in the past. Localities F-250-8 and F-350-1 yielded fluffy efflorescences typical of most of the mine; these apparently form in dry parts of the mine as small quantities of ground water reach the walls and evaporate.

The sulfate sample localities are related to known ore bodies as follows. Sample F-250-8 lies between 50 and 100 feet beneath and to the east of the stope developed in the Sweeney lease, one of the largest single ore bodies in the district (Ransome, 1909, p. 154, 225-228; Newmont Mining Corporation, unpublished maps). Localities F-350-3 and F-350-4 lie about 120-200 feet from the Sweeney stope, a few tens of feet to the south and east of a vertical projection of the stope to the 350-foot level. Another smaller stope lies approximately 60-100 feet above and immediately to the south of these two sample localities. A stope approximately 250 feet above the localities was entirely of oxidized ore (Ransome, 1909, p. 228). Locality F-350-1 is from the wall of a stope along a fault that may continue to the northeast into the Engineers' lease (Ransome, 1909, pl. XXXV, p. 232). Localities F-350-8 and F-350-9 lie between 120 and 230 feet below and to the west of the Sweeney stope. No ore bodies are known to have been mined from the ground immediately above these samples.

Most of the mine workings from which the sulfates came were made between 1903 and 1905 (Ransome, 1909, p. 225-226 and plate XXXV; M. C. Duffy, oral commun., 1966). The tunnel from which samples F-350-8 and F-350-9 came (fig. 3) is a crosscut driven in about 1919 (Searles, 1948, p. 20). Thus the sulfate coatings, which were sampled in September 1966, are the result of 47 to more than 60 years of supergene leaching of low-grade unmined silicified rocks, and possibly small unknown bodies of high-grade ore.

By comparing amounts of elements shown in table 6 with amounts shown in figure 6, the potential indicator elements for gold can be qualitatively arranged in order of decreasing mobility as follows: zinc, molybdenum, copper, bismuth, silver, lead. Information is inadequate or lacking for gold, arsenic, and mercury. This arrangement must be approximate because geochemical information is lacking for average-grade ores taken from the Florence mine. Silver was unusually scarce in ores from

TABLE 6.—Spectrographic analyses of supergene hydrated sulfates, Florence mine

[Analyst, Harry Bastron. N, not detected at limit of detection, which is given in parentheses in ppm. All other figures in ppm. Data for other ore-related elements are: Au, N(15) for all samples; Pb, N(7) for all samples; As, N(200) for all samples; Cd, N(50) for all samples; Sb, N(100) for all samples except 700 for F-350-3A; Sn, N(7) for all samples; Te, N(1000) for all samples. Other elements present in notable amounts include Mn (30-300), except for F-350-3A with 3, Co (50-1,000), except for F-350-3A with N(2), Ni (15-500), except for F-350-3A with N(1)]

Sample	Mineralogy	Ag	Bi	Cu	Mo	Zn
F-250-8	Halotrichite (Fe,Mg)Al ₂ (SO ₄) ₄ ·22H ₂ O	N(1)	10	15,000	30	1,500
F-350-1A	Halotrichite	N(1)	20	5,000	15	700
1B	Melanterite FeSO ₄ ·7H ₂ O	N(1)	30	700	N(2)	1,000
4A	Copiapite (Fe,Mg)Fe ₃ (SO ₄) ₆ (OH) ₂ ·20H ₂ O	N(1)	20	3,000	10	1,500
4B	Halotrichite-coquimbite Fe(SO ₄) ₂ ·9H ₂ O mixture	N(1)	50	2,000	10	1,000
8	Halotrichite-rozenite FeSO ₄ ·4H ₂ O mixture	N(1)	10	50	N(2)	3,000
9	Rozenite FeSO ₄ ·4H ₂ O	N(1)	N(7)	200	7	2,000
3A	Gypsum CaSO ₄ ·2H ₂ O	3	70	100	N(2)	N(100)

the Florence (Ransome, 1909, p. 230), so silver might be more mobile than indicated.

Secondary sulfates such as those analyzed here were used by Lovering (in Morris and Lovering, 1952) to determine supergene mobilities of gold, silver, lead, copper, and zinc in the Tintic district, Utah. His results generally agree with ours, even though his samples contained larger amounts of these metals, and he considered differences in mobility related to several different wallrock environments.

IRON AND MANGANESE

Iron and manganese are included in table 5 because they are both easily oxidized and precipitated as hematite, goethite, and various manganese oxides and hydroxides. Several other elements, among them arsenic, copper, molybdenum, and zinc, may be precipitated with these minerals or absorbed by them (Hawkes and Webb, 1962, p. 162-177)

Iron does not seem to show consistent preferences for any lithology or structural environment. Many high and very high iron values are associated with fault zones, but most such values are not (see pl. 4). Unaltered dacite, unoxidized silicified dacite, and unoxidized average-grade ores contain 5, 5 and 7 percent iron, respectively (geometric means, see fig. 6 and table 2), but the oxidized silicified dacite and oxidized argillized dacite of the cuts average only 1 and 2 percent iron, respectively (see histograms, pl. 4, and table 4). Thus, even though hematite and limonite stain many of the rocks of the cuts conspicuously, much iron has been removed. Nearly all iron is retained during hydrothermal alteration and ore deposition except in the high-grade ores, which occurred in relatively small volumes (fig. 6); the iron removed from the cuts, therefore, must have been leached during oxidation. In the few unoxidized argillized rocks we have examined from the Florence mine and elsewhere in the Goldfield altered area, pyrite generally replaces former mafic minerals just as it does in unoxidized silicified rocks. Before oxidation, therefore, the amounts of iron in silicified and argillized rocks must have been similar, so that the oxidized silicified rocks were more strongly leached than the oxidized argillized rocks. The most likely explanation for this is that numerous small postalteration fractures remain open in the oxidized silicified rocks, whereas in oxidized argillized rocks they were squeezed shut. These small fractures have diverse orientations and are easily visible in the silicified rocks along the cut walls. Locally, they are so abundant that from a distance the rock looks brecciated. The same small fractures in argillized rocks, in contrast, are much tighter and can only be seen readily on freshly excavated surfaces. The histograms show that both oxidized silicified and argillized rocks have a wide range of iron values.

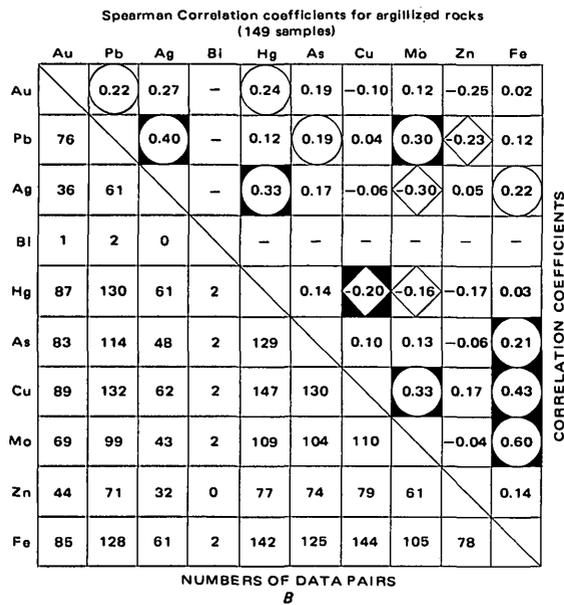
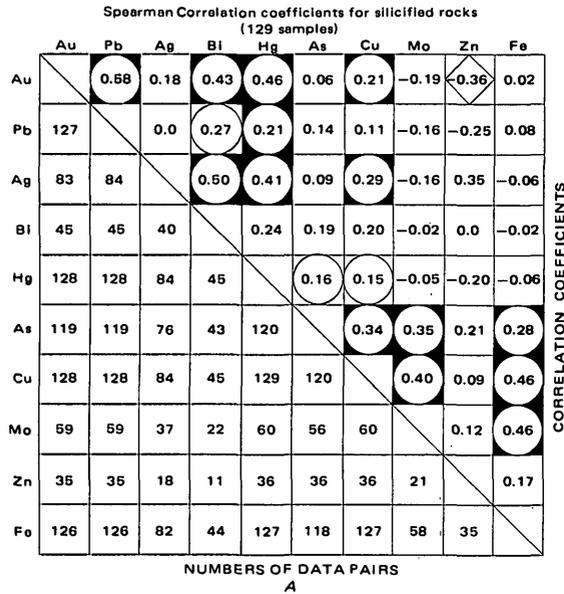
Differences in porosity, permeability, and other properties affecting movement of ground water and reactivity of groundwater solutions can probably explain details of the iron distribution map. The present petrographic division of the data, in spite of the obvious differences in physical properties between silicified and argillized rocks,¹⁵ is inadequate for evaluating these factors. Iron, even though it is quite immobile once it forms limonite, has clearly been considerably redistributed during oxidation at Goldfield. The iron map can be compared with the maps for potential indicator elements to help assess the extent of supergene dispersion of each element.

Manganese should behave in the same way iron does during oxidation (see table 5). Manganese, like iron, is depleted in oxidized silicified rocks (geometric mean 15 ppm) relative to oxidized argillized rocks (geometric mean 100 ppm) (see table 4), but manganese, unlike iron, is strongly and progressively depleted during hydrothermal alteration and ore deposition. (See fig. 6 and section on "Petrography of Unoxidized Altered Rocks and Ores".) It seems likely that manganese was removed from both silicified and argillized rocks of the cuts during hydrothermal alteration, and probably more was removed at that time from silicified rocks. The secondary sulfates previously described show 30-300 ppm manganese; this amount of manganese indicates some movement during oxidation. Manganese, therefore, was probably removed during both hypogene and supergene alteration so that it is of little use for determining whether other elements have undergone supergene redistribution; consequently, a manganese distribution map is not included, and manganese is not considered further.

CORRELATION MATRICES

The correlation matrices for the potential indicator elements and iron (fig. 7) facilitate comparisons between them and provide a summary of the results. The statistical methods used to generate each matrix are discussed in the section on statistical methods. The upper triangle of each matrix gives the correlation coefficients. The lower triangle gives the number of data pairs used for calculating each coefficient; if either or both values of a data pair were outside the detection limits, that data pair was rejected. The maximum correlation coefficient is 1.0, which corresponds to perfect correlation and ranked lists of samples for each of the two elements being compared would be identical. A correlation coefficient of zero indicates complete absence of correlation, and a coefficient of -1.0 indicates perfect negative correlation, in which case ranked lists would

¹⁵An exception is the advanced argillic rocks (12 samples), included with silicified rocks because of their alunite-bearing mineral assemblages. These rocks appear physically similar to argillized rocks. (See section on "Petrography of Oxidized Altered Dacite Samples.")



EXPLANATION

-  Correlation coefficient not significant at 95 percent confidence level
-  Negative correlation coefficient significant at 95 percent confidence level but not at 99 percent confidence level
-  Positive correlation coefficient significant at 95 percent confidence level but not at 99 percent confidence level
-  Negative correlation coefficient significant at 99 percent confidence level
-  Positive correlation coefficient significant at 99 percent confidence level

FIGURE 7.—Spearman correlation coefficients for oxidized rocks from the Combination-January area. A, Silicified rocks (129 samples). B, Argillized rocks (149 samples).

be exactly reversed. By no means are all the positive correlation coefficients large enough to constitute significant positive correlations, nor are all the negative correlation coefficients close enough to -1 to constitute significant negative correlations. As the number of data pairs increases, however, the smallest coefficient that may be considered significant at a given statistical level of confidence becomes progressively smaller. Coefficients statistically significant at the 99-percent-confidence level and coefficients statistically significant at the 95-percent-confidence level but not at the 99-percent-confidence level are each designated in the matrix. All other coefficients are taken to indicate no significant correlation. The numerical value of a given correlation coefficient is of little importance; it is important only that the value be large enough, considering the number of data pairs used, to indicate a significant degree of positive or negative correlation. The statistical levels of confidence provide arbitrary but objectively defined cutoffs for deciding which correlation coefficients are large enough to be considered geologically important. Coefficients significant at the 95-percent-confidence level are assumed to indicate a meaningful association or correlation in the geologic context, and coefficients significant at the 99-percent-confidence level are assumed to indicate a strong correlation.

In the following discussion gold is presented first and the remaining ore-related elements are presented in order of increasingly strong supergene leaching and redistribution. The position of bismuth in this order is rather arbitrary because most of the analytical data for bismuth fall below the detection threshold.

INTERPRETATION OF DATA FOR THE POTENTIAL INDICATOR ELEMENTS
GOLD

The gold distribution pattern in the Combination-January cuts (pl. 3) is mainly the result of hypogene dispersion processes little modified by supergene dispersion and therefore is mainly a relict primary dispersion pattern. Some parts of productive silicified zones were not ore grade, but most of the ore, whether primary or oxidized (above 130-180 feet depth), was from silicified zones (pl. 1). The moderate and high gold values in the cuts are almost entirely within silicified zones, so the low low-tenor oxidized silicified rocks of the cuts must belong to a hypogene gold aureole connecting and extending outward from the ore bodies but restricted to the silicified zones. The fact that the ore bodies had assay walls (Ransome, 1909, p. 213, 218; Collins, 1907b, p. 435) is consistent with this conclusion.

Some supergene movement of gold might be expected, since gold is thought to be capable of at least a moderate

degree of mobility (table 5), but supergene dispersion has not greatly modified the relict primary dispersion pattern. Both Ransome (1909, p. 170-174, 216) and Spurr (1905, p. 138) believed that the gold of rich oxidized ores, some of which occurred with limonite in fractures, was concentrated to some degree during oxidation, but even where notable enrichment occurred, rich sulfide ore probably existed previously. All the gold-bearing samples found along faults in oxidized argillized rocks (three high and two intermediate gold values) have high iron contents resulting from abundant hematite or hematite-goethite mixtures (see loc. 6 (two samples), 5, 9, and 18, pl. 3 and 4). The abundant ferric oxide and hydroxide indicate that the high Eh's (0.9 volt or more) and low pH's (less than 2 to 5) necessary to dissolve gold may well have developed at these localities. (See Cloke and Kelly, 1964.) These faults may have formed, however, before hypogene activity ceased; if so, gold might have been transported to these sites by either hypogene or supergene processes, or both, since hypogene gold left along faults might be particularly susceptible to supergene mobilization. The correlation diagrams (fig. 7), furthermore, show no significant gold-iron correlation for either silicified or argillized rocks, indicating that supergene dispersion of gold cannot be generally important, even if gold moves short distances to produce enrichment along fractures. This result agrees with Cloke and Kelly's (1964) data on gold solubility and Krauskopf's (1967) calculations and conclusion that significant migration of gold occurs only locally and for short distances. Even if gold moves as much as a few feet, the effects would not be visible at the scale of sampling of a geochemical exploration program.

LEAD

The map pattern for lead is a relict primary dispersion pattern very similar to that for gold (pl. 3). Lead is generally thought to be immobile during oxidation (table 5) because it forms a very stable sulfate (anglesite, $PbSO_4$) and carbonate (cerussite, $PbCO_3$). It is not found in supergene sulfates from the Florence mine (see section on "Mobility of Elements in the Zone of Oxidation"). Anglesite is likely the predominant lead-bearing mineral in the oxidized zone. Lead values tend to show smaller changes between adjacent samples than do gold values (compare geochemical profiles, pl. 3); this fact indicates that lead is more evenly distributed through the rocks than gold is. Since lead should be less mobile than gold during oxidation, we infer that this even distribution is mainly, if not entirely, a hypogene rather than supergene feature. The correlation diagrams show that gold and lead are correlated in argillized rocks and strongly correlated in silicified rocks.

Two features shown by the histograms for lead (pl. 3)

are presumably the result of hypogene processes: the negatively skewed distribution of logarithms of lead values in oxidized silicified rocks (see p. 29) and the bimodal distribution of lead in oxidized argillized rocks. The histogram for gold in silicified rocks has a distinct upper tail that would be even better developed if mined-out ore bodies intersected by the cuts had been sampled. With the strong correlation between lead and gold in oxidized silicified rocks and the similarity between the lead and gold maps, we would expect the histogram for lead to show a better developed upper tail. The histogram for lead in oxidized silicified rocks shows instead a sharp drop above 700 ppm, with very few values of 1,000 ppm or more. Few values greater than 1,000 ppm occur in either average-grade or high-grade ores (fig. 6). Amounts of lead in these two groups of samples are similar, whereas all other ore-related elements show at least some enrichment in the high-grade ores, and most show considerable enrichment. Another manifestation of this apparent ceiling on lead values was the paucity of lead-bearing minerals in the ores, although some lead production is recorded (U.S. Geol. Survey, 1912-24, U.S. Bur. Mines, 1934-1946). Ransome (1909, p. 112) reported galena from only a few localities in the main district. No lead minerals have been reported in either oxidized or unoxidized ores of the Combination and January mines. Preliminary microprobe examination of one unoxidized average-grade ore sample by G. K. Czamanske shows that neither farnatite nor tetrahedrite-tennantite contains as much as 0.1 percent lead, but bismuthinite may contain amounts on the order of 0.5 percent. The relative scarcity of lead thus seems to be characteristic of the Goldfield district and most likely results from a lack of available lead at the source of the ore-bearing solutions. Ores obtained in the deeper, eastern parts of the district contained considerable copper and tin (Searls, 1948, p. 17-18; Wilson, 1944); this fact suggests some zoning of those metals, but lack of information on lead content of the ores makes it impossible to evaluate zoning in the district with respect to lead.

Regarding the bimodal frequency distribution of lead in oxidized argillized rocks, the lower mode lies below the average amount of lead in unaltered dacite (-2.8 log percent or 15 ppm), and the upper mode lies above it, so some rocks have been depleted and other rocks have been enriched in lead. The dacite represented by the lower mode was probably leached of lead during the hydrothermal activity that produced argillization. Most of the values comprising the upper mode, in the range from 20 to 150 ppm, are found in fault zones or within 10 feet of silicified zones or fault zones. The 20-150 ppm values near silicified zones likely represent a narrow hypogene aureole extending from the silicified zones a

short distance into the argillized zones. If most of the faults originated during the later stages of hydrothermal alteration, the values associated with these structures could also represent low-tenor hypogene metallization. We have no explanation for localities enriched in lead but devoid of structure, such as that north of locality 6 where four high values appear. We infer that igneous lead was leached from the dacite during the earlier stages of hydrothermal activity, and ore lead was added locally to the resulting argillized rocks during the later stages of hydrothermal activity. Other ore-related elements may have had a similar history in argillized rocks, but if so, ranges of values, detection limits, and supergene redistribution effects obscure the bimodal frequency distributions.

SILVER

Almost all intermediate and high silver values are found in the silicified zones; the highest values occur in the same general areas as those in which high gold values occur. This fact argues against much supergene movement of silver, even though silver often shows at least moderate supergene mobility (table 5). Supergene silver mobility is relatively low at the Florence mine, as deduced from the analyses of secondary sulfates (see section on "Mobility of Elements in the Zone of Oxidation"). Ransome (1909, p. 119-120, 171) reported chlorargyrite (cerargyrite, AgCl) and probable minor embolite ($\text{Ag}(\text{Cl}, \text{Br})$) in the oxidized zone at Black Butte and McMahan Ridge, 3 miles northeast of the main district. Much of the ore in that part of the Goldfield altered area was oxidized, yet it generally had higher silver-to-gold ratios than ores from the main district (Ransome, 1909, p. 246-251). Schaller (1941) reported probable minor iodyrite in oxidized ore that likely came from the Combination-January area. Burgess (1911) reported silver halides in the Tonopah district, 25 miles north of Goldfield. In the upper part of the oxidized zone at Tonopah, silver was not carried far from the original sulfide ore before it was precipitated as chlorargyrite, the most abundant silver halide mineral. Boyle (1968, p. 188-207) indicates that much silver should remain in the oxidized zones of sulfide ore deposits in semiarid and arid areas; silver halides should be the most abundant silver minerals in the upper parts of the oxidized zones. The foregoing observations point to a relatively low supergene mobility for silver in the oxidized zone at Goldfield and indicate that the silver map shows mainly a relict hypogene pattern.

Silver and iron are positively correlated in oxidized argillized rocks; this correlation indicates some movement of silver and redeposition with limonite. Silver therefore must be more mobile than lead. The

supergene mobility of silver relative to gold is difficult to determine on the basis of association with limonite because gold is associated with abundant limonite minerals at several conspicuous localities, but overall, gold and iron are not correlated (see p. 35).

Although high gold and silver values occur in the same areas, gold and silver show no significant correlation in oxidized silicified rocks or argillized rocks; this lack of correlation is probably mainly a hypogene feature. Wilson (1944) analyzed silicified rock samples from the Goldfield Consolidated main vein (Jumbo Extension mine, 830-foot level), Clermont vein (Clermont mine, 225-foot level), and from two surface localities, one of which is on the Jumbo vein (fig. 2, see "Introduction"). He found a consistent relation between gold and silver in the vein on the Jumbo Extension 830-foot level, but he did not find a consistent relation at the other three localities. We can gain some information by comparing other ore-related elements with gold and silver in oxidized silicified rocks. Bismuth, mercury, and copper all show residual highs northeast of the January shaft in spite of supergene effects, which are particularly important for copper. These three elements correlate with both gold and silver, but because gold-silver and lead-silver correlations are conspicuously missing from this tightly knit group of undoubtedly hypogene element associations the variations in gold-silver ratio probably have a significant hypogene component.

The gold-silver ratios in figure 8 have a wide range (15:1 to 1:50), and the plotted points show considerable scatter; the scatter accords with the lack of statistical correlation. Analytical error for both gold and silver likely accounts for a good deal of the scatter, as the one-standard-deviation boxes accompanying figure 8 show. Sampling error related both to field sampling and to removal of analytical portions may be a problem with gold values (see p. 19) in addition to the usual analytical error. Supergene redistribution of both elements, even though we consider it insignificant in terms of the geochemical maps, probably also accounts for some of the scatter, since leaching may have somewhat changed the original gold-silver ratios in some samples. The correlation data discussed above suggest that a significant part of the data scatter is also due to differences in the proportion of gold and silver deposited by the ore-bearing fluids. However, sampling and analytical error aside, we cannot determine precisely how important supergene versus hypogene effects were in producing the wide range of gold-silver ratios without being able to compare gold-silver ratios for oxidized and unoxidized parts of individual ore bodies in the Combination-January vein system.

Despite the wide range in gold-silver ratios, (fig. 8)

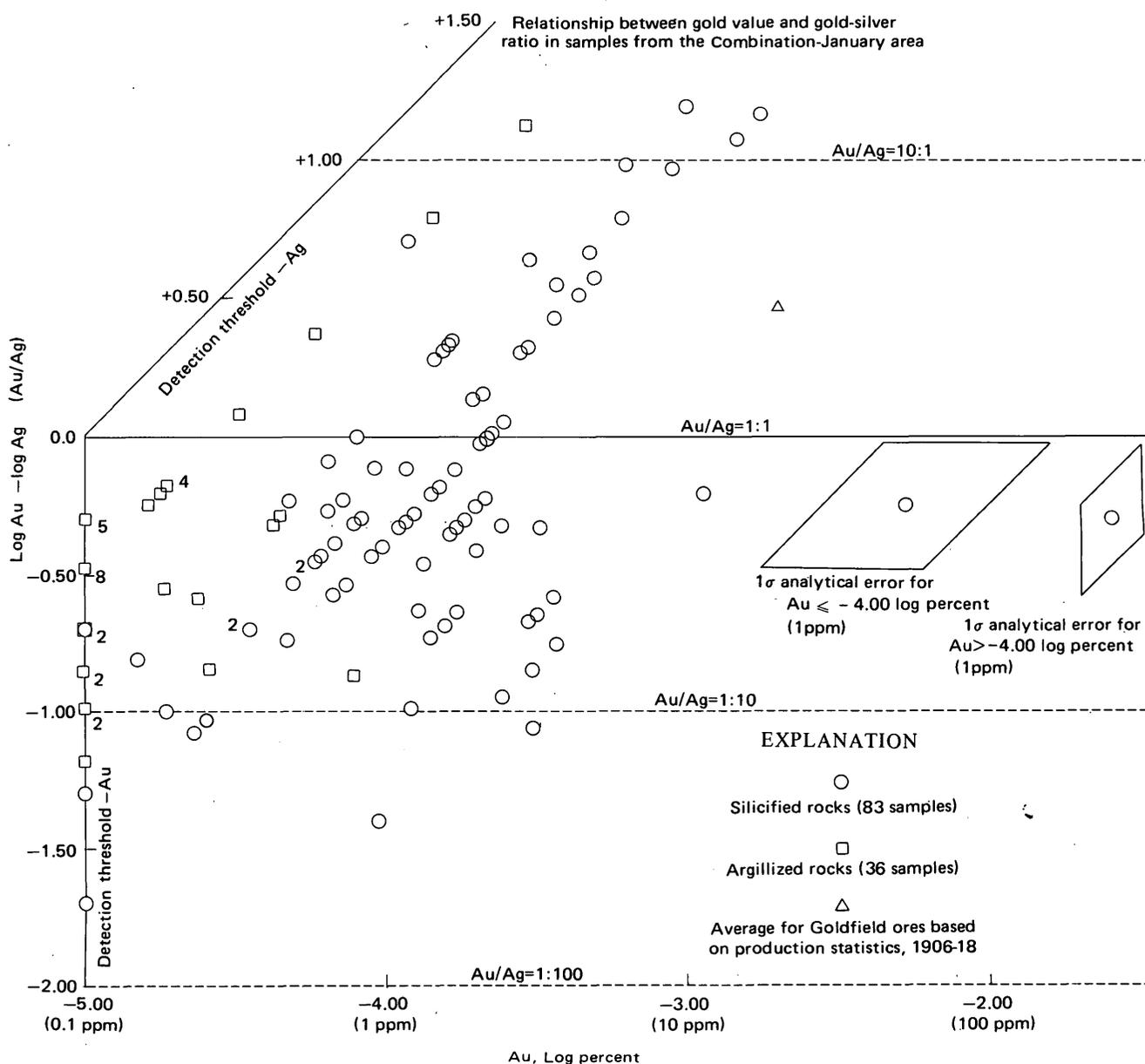


FIGURE 8.—Relation between gold value and gold-silver ratio in samples from the Combination-January area.

the ratios generally increase with increasing gold values; if a significant part of the data scatter is due to hypogene processes, this trend is probably also the result of hypogene processes. The high ratios at high gold values cannot be satisfactorily explained by supergene leaching of silver relative to gold in richer ores, because production data from Ransome (1909) and from U.S. Geological Survey statistics (1903-18) indicate that high gold-silver ratios were characteristic of most ore-grade material from the main district whether oxidized or unoxidized¹⁶ (table 7). If the increase in gold-silver

ratios with increasing gold values is indeed due to hypogene processes, the ore-mineral paragenesis should reflect this increase.

Tolman and Ambrose (1934) determined the ore-mineral paragenesis as pyrite and marcasite, followed by famatinite, tennantite, and sphalerite, followed by bismuthinite, followed by goldfieldite, followed by gold-silver tellurides and native gold. There is considerable overlap between adjacent minerals in the sequence. Tolman and Ambrose found at least small amounts of tennantite associated with famatinite in all the high-grade ore specimens they examined, but in a figure showing sequence of precipitation of the ore metals, they show both silver and gold being precipitated simul-

¹⁶The reverse is true for some ores from mines in outlying areas (Ransome, 1909, p. 171-172, 250).

TABLE 7.—Gold-silver ratios in Goldfield ores

Au value (ppm)	Au:Ag	Amount of ore (short tons)	Location of ore, and remarks	Reference
693	7.55:1	1,166	Upper levels of the Combination mine, best ore processed before 1905 (mostly oxidized).	Ransome, 1909, p. 171.
1,880	20:1	59	Upper levels of the Combination mine, best of the above lot of 1,166 tons (entirely oxidized).	Do.
3,460	28.8:1	Unknown	Florence mine, 250-foot level, unoxidized	Ransome, 1909, p. 230.
20,000 (2 percent)	8:1	Unknown	Composite sample of nine lots of ore from the Mohawk mine (early 1907). These and the following Mohawk mine samples unoxidized.	Ransome, 1909, p. 167.
4,500–12,400	5.0:1–12.9:1	Unknown, but small	Nine analyses of rich ore from the Mohawk mine. Analyses made on material recovered from ore thieves.	Ransome, 1909, p. 167, 169.
12,200–14,900	4.4:1–5.5:1	Unknown	Six analyses of rich ore from 220-foot level, Hayes-Monnette workings, Mohawk mine.	Ransome, 1909, p. 169.
20,900	8.1:1	47.8	Carload of ore shipped from Hayes-Monnette lease, Mohawk mine, January 1907. The richest carload of ore ever shipped out of the district.	Ransome, 1909, p. 172.
23	1:4	Hand sample	Combination mine, 230-foot level, unoxidized	Ransome, 1909, p. 166.
33.9	2.95:1	3,776,609	Based on total production for 1906–18, the main productive period. Mostly unoxidized.	U.S. Geological Survey, 1906–18.

taneously at the end of the ore paragenesis, thus implying that virtually all the silver accompanied gold late in the depositional sequence. According to Goldschmidt (1954, p. 190, 194), tennantite-tetrahedrite series minerals may bear even more silver than galena. In the average-grade ores we examined, all of which contain more silver than gold, pyrite and farnatinitite are generally the only abundant minerals that belong to the ore-mineral sequence; however, in several samples, subordinate amounts of tetrahedrite-tennantite are associated with the farnatinitite. Except for small amounts of bismuthinite and very small amounts of native gold, none of the other minerals characteristic of rich ores appear in the average-grade samples. Preliminary microprobe analyses suggest that tetrahedrite-tennantite is indeed an important host mineral for silver in the Goldfield ores, although the silver content of the tetrahedrite-tennantite is variable. Concentrations of 0.5–1.5 percent silver are common in tetrahedrite-tennantite, whereas farnatinitite contains less than 0.1 percent.

We suggest that silver accompanied copper early in the ore-metal sequence. Copper and bismuth continued into the middle of the sequence, but overlapped gold (and, by inference, lead), which were deposited late along with lesser amounts of silver. With this suggested two-stage introduction of silver, most of the silver in many of the ores could have been introduced early in the paragenesis. Also, the amount of gold introduced late in the paragenesis at any given spot could have been largely independent of the amount of silver introduced earlier. Bismuth, deposited in the middle of the paragenesis, and copper, deposited both early and in the middle, overlap both early silver and late gold and middle-to-late lead, producing several positive correlations between silver, bismuth, and copper, and be-

tween gold, lead, bismuth, and copper, but no correlation between gold and silver or lead and silver associated with hypogene aureoles in ore-bearing silicified rocks.

In oxidized argillized rocks, the gold-silver ratio is generally higher than it is for oxidized silicified rocks with comparable amounts of gold (fig. 8). No sulfide mineral other than pyrite has been reported from unoxidized argillized rocks, nor has any sulfide other than pyrite been found in our few observations of unoxidized argillized rocks in the Florence mine and elsewhere in the Goldfield altered area. Possibly, if the small amounts of lead, gold, and silver in these rocks were all introduced by ore-bearing fluids late in the paragenesis, that would explain the high gold-silver ratios but not the lack of correlation between gold and silver that persists in oxidized argillized rocks. Silver correlates with iron in argillized rocks, thus indicating different behavior and possibly a greater supergene mobility than it shows in silicified rocks, where it probably forms silver halides nearly in place. The strong lead-silver correlation in argillized rocks may also be due wholly or partly to supergene processes. Silver may be associated with lead-bearing oxidation products such as anglesite ($PbSO_4$) or plumbojarosite ($PbFe_6(SO_4)_4(OH)_{12}$) instead of silver halides. (See Boyle, 1968, p. 192–195.) Since lead moved little during oxidation, presumably the silver associated with lead moved to the sites of oxidizing lead-bearing minerals, but the silver need not have moved very far.

BISMUTH

Our data show that bismuth correlates with gold, lead, and silver in the Combination-January area in spite of oxidation (fig. 8). Wilson (1944) noted that bismuth correlated with gold, silver, and tin in vein material from the 830-foot level of the Jumbo Extension

mine, but these correlations did not exist at any of the other three localities he sampled (see "Introduction"). Our bismuth and silver maps are similar (pl. 3) although more samples have undetectably small amounts of bismuth than silver. Because the bismuth content of many samples is below the detection threshold, effects of oxidation are difficult to evaluate. There are only two oxidized argillized samples with detectable amounts of bismuth, so correlation coefficients cannot be calculated for argillized rocks. Since bismuth in silicified zones, however, correlates with gold, lead, and silver, all of which show relict hypogene dispersion patterns, the bismuth map (pl. 3) also shows a relict hypogene pattern. On the other hand, Ransome (1909, p. 121-123, 213, 219) reported bismite (Bi_2O_3) in oxidized ore, in some places partially filling prismatic cavities in quartz left by leaching of bismuthinite (Bi_2S_3). The supposed bismite was subsequently reidentified by Schaller (1941) as bismoclite (BiOCl), another secondary bismuth mineral. Ransome's observations thus indicate partial removal of bismuth during oxidation, as do bismuth contents of the secondary sulfate samples (see section on "Mobility of Elements in the Zone of Oxidation"). Data for bismuth obtained by a more sensitive analytical method, therefore, might well reveal some definite supergene effects. Analyses with a detection limit of at least 0.5 ppm instead of 5 ppm would probably be necessary to provide adequate data for bismuth.

MERCURY

Mercury correlates strongly with gold, lead, and silver in oxidized silicified rocks and with gold and silver in oxidized argillized rocks (fig. 7); these correlations indicate that hypogene processes were important in producing the features seen on the mercury map (pl. 3). These relations are somewhat difficult to see by comparing the mercury map with the gold, lead, and silver maps, owing to the rather small total range of mercury values and strongly overlapping ranges for silicified and argillized rocks. (See histograms, pl. 3.) In oxidized silicified rocks mercury also correlates with copper, as do silver and gold; much copper was leached during oxidation, but enough remains to give correlations with these three ore-related elements (see p. 42). Mercury thus forms a hypogene dispersion aureole extending outward from the ore bodies but restricted to silicified rocks, just as gold, lead, and silver do.

Mercury is unique in that secondary dispersion can occur by diffusion of mercury gas. Mercury probably has low mobility in the low pH and moderate to high Eh solutions that must have been involved in oxidation at Goldfield (Krauskopf, 1967, p. 516). Diffusion of mercury gas, therefore, probably accounts for most

posthydrothermal movement of mercury away from the silicified zones at Goldfield if significant secondary migration indeed occurred. Migration of mercury gas conceivably could have become more important than hypogene dispersion as hydrothermal activity waned and could have continued to the present, regardless of when oxidation took place. If various sulfide minerals, however, carried most of the mercury in the ores, then little mercury was free to disperse until the sulfides were destroyed by oxidation.

Although some of the features of the geochemical map and some of the element correlations may be explained by gaseous diffusion, we believe that hypogene dispersion alone provides an adequate explanation. Gaseous diffusion of mercury might explain the fact that differences in mercury values between adjacent samples in the cuts are mostly rather small, diffusion having evened out sharp variations. On the other hand, the lack of distinct gradients outward from silicified zones argues against extensive supergene migration of mercury gas. Intermediate and high mercury values between localities 3 and 4 may represent a narrow mercury halo around the silicified zone exposed in the cut wall northwest of locality 4 (see p. 30). This is the only area within the cuts showing a halo, but it is adjacent to a particularly wide segment of the Combination-January vein system (pls. 1 and 2), and the vein material to the northwest is definitely enriched in mercury. It is difficult to explain the narrow mercury halo between localities 3 and 4 as being due solely to diffusion, however, because there is no evidence for a diffusion gradient, and it is hard to understand how several samples at localities 5 and 6 escaped being enriched with mercury.

Some element correlations could be the result of gaseous diffusion of mercury, but probably are not. Mercury is correlated with gold in oxidized argillized rocks, as well as oxidized silicified rocks; this correlation could result from hypogene association or from amalgamation of gaseous mercury with native gold, or both. But mercury is also strongly correlated with silver in both silicified and argillized rocks, and free native silver has not been reported in any oxidized Goldfield ores (Ransome, 1909, p. 171). Silver in the oxidized zone is probably present mainly as silver halides, or, in argillized rocks, it may be associated with oxidized-zone lead-bearing minerals (see p. 37). We do not know how silver and mercury might be associated mineralogically in the oxidized zone. Thus the mercury-gold and mercury-silver correlations may or may not be the result of gaseous diffusion of mercury, but the mercury-silver correlations more probably are not. Gold and silver, regardless of whether they have undergone some

supergene movement, still show dominantly hypogene patterns, so regardless of whether gaseous diffusion played an important role, the mercury-gold and mercury silver associations in these rocks cannot be taken as evidence for supergene dispersion of mercury. Mercury shows negative correlations with copper and molybdenum in argillized rocks: both copper and molybdenum have undergone considerable supergene redistribution in argillized rocks, as will be explained later (see p. 42 and 44). If gaseous diffusion effects were predominant, we would expect to see fewer and weaker correlations between mercury and other metals in oxidized silicified rocks, and no significant correlations, except possibly with gold and less likely with silver, in oxidized argillized rocks. We infer that hypogene dispersion features dominate the mercury map.

With the strong association between mercury and gold, lead, and silver in silicified rocks, the lack of correlation between mercury and bismuth is surprising. Published descriptions of mineral paragenesis are of no help because mercury-bearing minerals have not been reported from any part of the main district, even from high-grade ores, although mercury definitely was enriched in the ores (fig. 6, and Ransome, 1909, p. 113). Relatively large amounts of mercury are known to occur in tetrahedrite-tennantite (Ramdohr, 1969, p. 554; Chan, 1969). This possible association could explain the correlation with silver, which also occurs in tetrahedrite-tennantite, but it does not explain the association with gold and lead. Without a detailed investigation of the amounts of mercury in all the various ore minerals, we cannot attempt further explanation.

The analytical data for unoxidized silicified rocks, average-grade ores, and high-grade ores (fig. 6) show much more mercury in these groups of samples than in samples from the cuts. Although much mercury might have been lost from the oxidized silicified rocks of the cuts, presumably by secondary migration, we hesitate to compare the data of figure 6 with those of the cuts because the high-grade ore samples, low-grade ore samples, Florence mine samples, and unaltered dacite samples were prepared by a different laboratory using different procedures than were used for samples from the cuts. Different sample preparation procedures can produce greatly different mercury yields from the same sample, owing to loss of mercury during grinding (Crosby, 1969, p. 189-191). Relative differences between samples done by a given method tend to be retained if the samples are treated differently and rerun, even though absolute amounts of mercury obtained may be considerably different. Thus there should be no problem making comparisons between groups of samples from the cuts and between the groups of sam-

ples shown in figure 6, but because preparation procedures differed, we cannot compare the former body of data with the latter one.

Secondary dispersion of mercury to form anomalies in soil or other overburden above ore bodies is very common and has been documented in many studies but holds little promise as a geochemical exploration technique at Goldfield. To produce these anomalies, mercury is transported as gas, in solution, or by mechanical movement of mineral and rock fragments; the relative importance of these three mechanisms varies from place to place depending on permeability and adsorptive capacity of the soil or overburden, climate, and topography (Koksoy and Bradshaw, 1969). Often primary dispersion aureoles exist along with the secondary halos but not in every district even if secondary halos in soil are well developed. (See particularly Friedrich and Hawkes, 1966.) The Goldfield ore bodies are deposits with limited primary dispersion of mercury because hypogene aureoles are mostly restricted to silicified rocks, and gas-phase dispersion has not substantially modified the primary dispersion pattern. Similar relations have been observed in several other districts: Pachuco Real del Monte, Mexico (Friedrich and Hawkes, 1966), Achisai, Kazakhstan (Furzov, 1958), Ivrandi, Turkey (Bradshaw and Koksoy, 1968), and probably Cripple Creek, Colorado (Gott and others, 1967). We did not attempt a soil survey for mercury in the Combination-January area because much of the surrounding area is covered with mine dumps or otherwise disturbed. Since mercury at Goldfield probably does not move in solution during oxidation and since relatively little has moved in the gas phase, soil anomalies could form only by mechanical dispersal of mercury-bearing silicified rock detritus. Low to moderate topographic relief throughout the altered area and low anomaly contrast between oxidized metallized silicified rocks and surrounding oxidized argillized rocks limit the possibilities for developing mercury soil anomalies at Goldfield.

ARSENIC

Arsenic shows a strong correlation with iron; this correlation indicates significant supergene redistribution. The arsenic map, however, also shows at least one definite relict hypogene feature: a group of high and intermediate arsenic values in silicified rocks northeast of the January shaft, an area with particularly high gold, lead, silver, bismuth, and mercury. This relict hypogene feature is less pronounced than it was for the foregoing elements, and correlation with gold, lead, silver, and bismuth is lacking, although correlation with mercury persists. As noted previously (see p. 30), silicified rocks in other parts of the cuts do not show a consistent rela-

tion between gold and arsenic. Oxidized silicified rocks have enough residual arsenic so that their average arsenic content is higher than the average arsenic content of oxidized argillized rocks. The preceding dominantly hypogene elements are more abundant in silicified than in argillized rocks. More severe leaching can reduce the average amount of an element in oxidized silicified rocks to a figure below that for oxidized argillized rocks, as is true for iron (see section on "Iron and Manganese"). We conclude that arsenic has undergone some supergene redistribution throughout the area, although the hypogene pattern has not been completely erased northeast of the January shaft.

The arsenic-copper and arsenic-molybdenum correlations in oxidized silicified rocks are revealing because both copper and molybdenum have also been partly leached during oxidation, as will be described later. The copper and arsenic in oxidized silicified rocks were both derived from famatinite,¹⁷ which was relatively abundant even in low-grade ores, and also from smaller amounts of tetrahedrite-tennantite. Famatinite and tetrahedrite-tennantite in the silicified rocks were oxidized along with pyrite, releasing iron and antimony along with the copper and arsenic. No molybdenum minerals have been reported in the ores, so without analyses for individual ore minerals, the paragenetic relations of molybdenum are unknown. Even though considerable iron was removed from silicified rocks during oxidation, enough remained to produce the strong iron-copper-arsenic-molybdenum association, which must be due to sorption of all three elements on limonite (note the strong copper-iron and molybdenum-iron correlations in silicified rocks) and probably also to coprecipitation of hydrated iron arsenates (particularly scorodite, $\text{Fe}(\text{AsO}_4) \cdot 2\text{H}_2\text{O}$), copper and copper-iron arsenates and hydrated arsenates, and possibly hydrated iron molybdate (ferrimolybdate, $\text{Fe}(\text{MoO}_4)_3 \cdot 8\text{H}_2\text{O}$) with limonite.

It is puzzling that arsenic does not correlate with copper and molybdenum in oxidized argillized rocks, especially since copper and molybdenum are strongly correlated there, and all three metals are again strongly correlated with iron. As mentioned earlier, we have never seen any sulfide other than pyrite in argillized rocks. Thus, any small amounts of arsenic and copper introduced into argillized rocks during hypogene metalization may have existed in forms other than famatinite and tetrahedrite-tennantite, and whatever mineral phases these were, perhaps they did not behave as famatinite and tetrahedrite-tennantite did during supergene leaching. The mineralogic composition of the argillized rocks, particularly the greater abundance of

clays relative to silicified rocks, may also have affected the mechanism of redeposition of arsenic and copper in the oxidized zone as the water table moved downward, although arsenic and copper are not associated with any particular clay mineral (see p. 42 and fig. 9).

Conditions in argillized rocks during oxidation probably favored formation of secondary lead-arsenic minerals, which could account for the lead-arsenic correlation in argillized rocks.

COPPER

With the exception of the high values in silicified rocks northeast of the January shaft, copper values in oxidized silicified and argillized rocks are similar (pl. 4). Average copper values for oxidized silicified and argillized rocks are essentially the same, and the histograms (pl. 4) confirm that the ranges of values for the two groups of rocks are similar.

Copper was the most abundant metal in both average and high-grade ores, and since the ores and their associated hypogene gold, lead, and silver aureoles were restricted to silicified rocks, the silicified rocks surely contained more copper prior to oxidation than did argillized rocks. Copper is relatively abundant in the unoxidized silicified rocks of the Florence mine (300 ppm geometric mean, table 2 and fig. 6). Before oxidation, silicified rocks of the Combination-January cuts likely had at least as much copper as the Florence mine silicified rocks and locally more. The average copper contents of oxidized silicified rocks and oxidized argillized rocks (geometric mean both about 15 ppm, table 4) are not much above the 10 ppm copper found in unaltered dacite (table 2 and fig. 6). Certainly, more copper has been leached from silicified rocks during oxidation than any other element yet discussed. Whether copper has been removed overall from the oxidized argillized rocks cannot be determined without comparing them to unoxidized argillized rocks.

Copper correlates strongly with iron in both oxidized silicified and argillized rocks, another indication that copper has undergone considerable supergene redistribution. Arsenic and molybdenum also correlate strongly with iron in both oxidized silicified and argillized rocks, and copper correlates with both these elements in silicified rocks and with molybdenum in argillized rocks to form an arsenic-copper-molybdenum-iron supergene association. We can offer no detailed explanation for the strong negative correlation between copper and mercury in oxidized argillized rocks; the cause is presumably greater supergene movement of copper relative to mercury. Many geochemical field studies, as well as laboratory studies on the solution chemistry of copper, have shown that copper is moderately to highly mobile in oxidizing

¹⁷Ransome's analysis of famatinite shows almost 50 percent Cu_3AsS_4 , the remainder of the mineral being Cu_3SbS_4 (Ransome, 1909, p. 118-119).

sulfide ores (table 5, and Garrels and Christ, 1965, p. 240). Our data support this conclusion (see also section on "Mobility of Elements in the Zone of Oxidation").

In spite of the relatively high mobility of copper, hypogene element associations in oxidized silicified rocks have not been completely destroyed, as shown by the high values that appear northeast of the January shaft (pl. 4) associated with high gold, lead, silver, bismuth, mercury, and arsenic values. Furthermore, correlations between copper and gold, silver, and mercury persist. As explained above, the copper-arsenic association is due primarily to their mutual association with limonite and therefore is mainly a supergene phenomenon, but hypogene association may contribute to this correlation indirectly by releasing from local ores both copper and arsenic together in relatively large amounts; consequently large amounts of both elements found their way into the limonite formed at these localities. Hypogene association could also contribute directly to the copper-arsenic correlation if the rocks northeast of the January shaft contain relict (unoxidized) disseminated famatinite and tetrahedrite-tennantite. If unoxidized sulfides exist in the samples from the cuts, however, they must be fine grained and small in amount, because we have not seen sulfide grains in the rocks, and we are convinced that substantial proportions of the iron, copper, and arsenic present before oxidation have been removed by supergene leaching. The copper remaining with gold, silver, and mercury must not be associated with limonite because none of these three elements correlate with iron. This copper could occur as azurite ($\text{Cu}_3(\text{CO}_3)_2(\text{OH})_2$), or malachite ($\text{Cu}_2(\text{CO}_3)(\text{OH})_2$), both reported by Ransome (1909, p. 108-109, 216) as rarely staining some oxidized and partly oxidized ores. It is unlikely that much copper resides in these two minerals, however, because pH values of solutions in the oxidized zone at Goldfield probably were generally too low to form them (Garrels and Christ, 1965, p. 240). We have not seen chrysocolla ($\text{CuSiO}_3 \cdot 2\text{H}_2\text{O}$) or turquoise-group minerals (particularly turquoise, $\text{CuAl}_6(\text{PO}_4)_4(\text{OH})_8 \cdot 4\text{H}_2\text{O}$, and chalcociderite, $\text{CuFe}_6(\text{PO}_4)_4(\text{OH})_8 \cdot 4\text{H}_2\text{O}$), and as far as we know, none of these minerals have been previously reported. Of the 39 oxidized silicified rock samples we X-rayed, 30 contained kaolinite, and 9 were free of kaolinite. Average amounts of copper for these kaolinite-bearing and kaolinite-free samples are essentially the same, and both are very close to the average for all 129 silicified rock samples. Copper thus is not notably associated with clay in the oxidized silicified rocks, and the form of copper associated with gold, silver, and mercury in these rocks remains unidentified.

In the oxidized argillized rocks, copper and other

elements that were mobile during oxidation could be associated with clays as well as with limonite because clay minerals are capable of ion exchange and sorption (Grim, 1968, p. 185-233; Carroll, 1959); however, we do not see this association. The argillized rocks of the Combination-January area all contain kaolinite and illite in various proportions, and 22 samples from the area north of locality 18 contain montmorillonite as well (pl. 2). Although pH of solution, clay-mineral particle size, and metal-ion concentration all affect the amount of metal sorbed by clays, capacity of the common clays to sorb copper, molybdenum, and zinc generally increases in the following order: kaolinite, illite, montmorillonite (Heydemann, 1959; Jones, 1957; Chu, 1969). Montmorillonite is particularly effective in sorbing many ore metals, mainly because of its large cation exchange capacity (Perel'man, 1967, p. 100). Cation exchange operates in the sorption of copper and zinc, whereas anion exchange operates for molybdenum and arsenic, which form molybdate (MoO_4^{-2}) and arsenate (AsO_4^{-3}) ions in solution. Molybdate and arsenate, however, readily form very insoluble compounds with ferric iron (ferrimolybdite, $\text{Fe}_2(\text{MoO}_4)_3 \cdot 8\text{H}_2\text{O}$, and scorodite, $\text{Fe}(\text{AsO}_4) \cdot 2\text{H}_2\text{O}$) so that we would expect the clays to be less important than iron in determining the supergene redistribution of these two metals. In the oxidized argillized rocks kaolinite, illite, and montmorillonite occur in various proportions; total clay contents generally are between 20 and 60 percent. Ideally, we should compare the abundances of copper, molybdenum, and zinc in rocks with known amounts of each clay mineral. Clay mineral percentages are difficult to estimate accurately, however, so we have merely divided the argillized rocks into three groups (fig. 9): montmorillonite-bearing, montmorillonite-free with illite dominant over kaolinite, and montmorillonite-free with kaolinite dominant over illite. The groups include only samples that we X-rayed in the course of our petrographic examinations. The three groups have similar iron contents; data for iron are included for comparison. Arsenic, copper, molybdenum, and zinc do not show significant differences between the three data sets, with the possible exception of zinc in kaolinite-dominant rocks. Since the average for zinc in these rocks may not be much below the detection threshold at -2.60 log percent (25 ppm), we cannot say definitely that clay content has an effect on zinc. Although the three data sets are not so precisely defined as we would like them to be with respect to relative amounts of the various clay minerals, we conclude that the clay content of argillized rock has little effect on supergene redistribution of the above four elements.

Copper commonly forms zones of supergene enrichment immediately below the water table, but no such

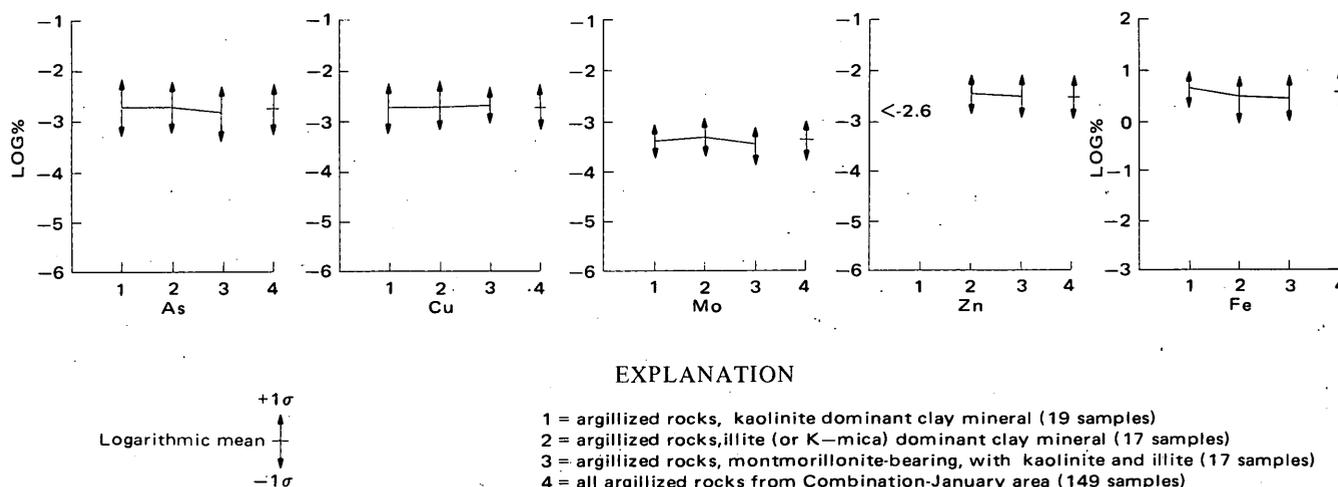


FIGURE 9.—As, Cu, Mo, Zn, and Fe in argillized rocks with various clay contents.

zone has been reported in the mines at Goldfield. Some enrichment, however, probably escaped notice because copper content was irrelevant in determining the worth of near-surface ores. Covellite (CuS) largely replaces tetrahedrite-tennantite and partly replaces famatinite in two of our unoxidized average-grade ore samples, showing that some supergene enrichment of copper took place at least locally. Perhaps not enough ore has been oxidized to produce a pronounced supergene enrichment zone; the pre-Siebert Tuff and present-day erosion surfaces in the Combination-January area probably truncate the upper parts of the lodes. Even if part of the copper from metallized silicified rocks moved laterally into the surrounding argillized rocks during oxidation, copper values are not consistently high in argillized rocks, since they are related particularly to limonite distribution, so that copper does not form a distinct and coherent supergene halo around ore-bearing oxidized silicified rocks. We have no way of knowing whether a hypogene copper aureole extended into the argillized rocks, but even if it did, it was destroyed during oxidation. Perhaps if the lodes were more deeply eroded, a supergene enrichment zone or a supergene halo, or both might be more apparent.

MOLYBDENUM

Some high molybdenum values occur northeast of the January shaft along with all the preceding elements, but features of the molybdenum map are largely the result of supergene redistribution (pl. 4). The relict hypogene association shown by rocks northeast of the January shaft is so weak that molybdenum shows no correlations with gold, lead, silver, bismuth, or mercury in oxidized silicified rocks (fig. 7). This lack of correlation is probably due both to greater supergene

mobility of molybdenum than any previously discussed element and to lack of pronounced enrichment of molybdenum in the ores. Although molybdenum is not so strongly enriched in the ores as are many other ore-related elements (fig. 6), during metallization molybdenum probably was somewhat enriched in silicified rocks relative to argillized rocks. The histograms show that oxidized silicified rocks contain less molybdenum than oxidized argillized rocks, although an average was not calculated for oxidized silicified rocks because less than half the silicified samples contained detectable molybdenum. The best evidence for substantial supergene mobility of molybdenum, however, is the similar behavior of molybdenum and iron.

The association between molybdenum and iron is as strong as the association between copper and iron, and it is readily visible by comparing the molybdenum and iron geochemical maps and profiles (pl. 4). Possible supergene minerals producing these associations have already been discussed in the section on arsenic, the most important molybdenum mineral probably being ferrimolybdate ($\text{Fe}_2(\text{MoO}_4)_3 \cdot 8\text{H}_2\text{O}$). Jones (1957) showed that hydrous ferric oxide is highly effective in sorbing molybdate (MoO_4^{-2}) anions from acid solutions. Significant amounts of molybdenum in the Florence mine supergene sulfates (see section on "Mobility of Elements in the Zone of Oxidation") show that water moving downward through oxidizing rocks does indeed contain molybdenum. We conclude that molybdenum, like copper, is relatively mobile in the oxidized zone, at least until solutions carrying it come in contact with limonite.

The correlation matrix for oxidized argillized rocks shows one important difference between the supergene behavior of copper and molybdenum: the strong lead-

molybdenum correlation. This correlation could be due to formation of wulfenite (PbMoO_4), which, although not reported at Goldfield, is a common secondary mineral in oxidized ore deposits containing lead. Takahashi (1960, p. 1105–1108) and Williams (1963, p. 1121–1122) have shown, however, that wulfenite is only conditionally stable in an oxidizing environment with sulfate and carbonate present. Since we do not know the mineral forms of lead and molybdenum in either silicified or argillized rocks prior to oxidation, we cannot investigate the lead-molybdenum correlation further, nor can we determine why lead and molybdenum are correlated in oxidized argillized rocks but not in oxidized silicified rocks. Molybdenum shows no correlation with calcium in either silicified or argillized rocks (not shown on fig. 7); so powellite (CaMoO_4) must not be an important supergene molybdenum mineral at Goldfield.

The relatively high supergene mobility of molybdenum presumably produced the negative molybdenum-mercury and molybdenum-silver correlations, just as relatively high supergene mobility of copper presumably produced the strong negative copper-mercury correlation.

ZINC

No vestiges of the strong hypogene metal concentrations northeast of the January shaft remain (pl. 4). The hypogene behavior of zinc must have been similar to that of the other ore-related elements (fig. 6), and consequently, it must have been enriched in the silicified rocks during metallization. Sphalerite (ZnS) appeared as a minor constituent in ores of the Combination mine (Collins, 1907a, p. 398). However, the histograms show that zinc is depleted in oxidized silicified rocks relative to oxidized argillized rocks. Furthermore, zinc shows no positive correlations with any of the preceding elements but does show negative correlations with gold in silicified rocks and lead in argillized rocks (fig. 7). Both the latter elements have undergone only minor supergene redistribution. We conclude that zinc has been strongly leached from the rocks of the cuts and leached more strongly from the silicified rocks.

The distribution of zinc in argillized rocks near silicified zones is too erratic to form a distinct halo (pl. 4). Zinc may be coprecipitated with limonite (Hawkes and Webb, 1962, p. 55, 164, 377), but in the study area zinc shows no correlation with iron, so it has not been partly retained in the oxidized zone by coprecipitation with limonite or sorption by limonite, as have arsenic, copper, and molybdenum. Sorption by clays probably was not effective in retaining zinc in the oxidized zone (see p. 42).

Apparently, zinc was more mobile during oxidation

than any other element considered in this study, as relatively large amounts of zinc in the Florence mine supergene sulfates attest (see section on "Mobility of Elements in the Zone of Oxidation"). High supergene mobility for zinc is in accordance with results of previous work summarized in table 5.

INDICATOR ELEMENTS FOR GOLD AND METHODS OF GEOCHEMICAL SAMPLING

Any geochemical exploration in the vicinity of Goldfield should be concentrated on the numerous silicified zones well exposed throughout the hydrothermally altered area. High values for gold, lead, silver, bismuth, and mercury, the elements showing dominantly relict hypogene dispersion patterns, are found mostly in silicified rocks. Even though all these elements except bismuth show at least a few intermediate and high values in argillized rocks, none of them consistently form hypogene aureoles extending a significant distance into argillized rocks. They do, however, form aureoles surrounding ore bodies within silicified rocks. The geochemical profiles constructed for gold, lead, and silver show that these elements in particular form aureoles that contrast sharply with much lower values found in adjacent argillized rocks. None of the elements that were notably leached and redistributed during oxidation, including arsenic, copper, molybdenum, and zinc, have moved outward from oxidized ore-bearing silicified zones into the surrounding oxidized argillized rocks to form distinct supergene halos.

Three of the nine ore-related metals considered in this report are potentially useful guides to ore for geochemical prospecting; usefulness of the remaining six metals is limited. Gold analyses are indispensable as a guide to ore. Lead is reliable as an ore guide and should be particularly useful for reconnaissance sampling programs because lead is even less mobile than gold during oxidation, and its aureoles are characterized by less sample-to-sample variation than accompanying gold. Silver analyses are also worthwhile because gold-silver ratios vary considerably, and amounts of silver cannot be predicted from gold or lead values. Amounts of silver exceeded associated amounts of gold in some ores, particularly in mines away from the main district (Ransome, 1909, p. 171–172), so potential ore bodies might well be missed if silver were not determined. We consider mercury optional in a geochemical survey because its aureoles are not distinguished by outstandingly high values. Information on mercury distribution might be more valuable in other parts of the Goldfield altered area than it is in the Combination-January area because Ransome (1909, p. 113) reported mercury showings at an otherwise unmetallized locality about 4 miles northeast of the

main district. Our data are inadequate to evaluate bismuth fully, so we cannot determine how useful bismuth might be in a geochemical survey. Arsenic, copper, and molybdenum are too strongly leached to detect anything but a fairly near-surface, extensive, and relatively high-grade ore occurrence such as that northeast of the January shaft; that is, an occurrence that likely would have been discovered already. Zinc is so strongly leached during oxidation that it seems useless as an indicator. We cannot rule out the possibility that arsenic, copper, molybdenum, or zinc could form well-developed supergene halos extending into oxidized argillized rocks around ore bodies in other parts of the Goldfield altered area, but from the results of this study, we cannot commend a sampling program for these elements utilizing bedrock samples from argillized rocks.

Realizing that our data are derived from only a small part of the Goldfield altered area and that geochemical relationships may well be different elsewhere in the area, we tentatively suggest that the following minimum gold, lead, and silver values be considered anomalous for bedrock samples from silicified zones. A geochemical survey should not miss any significant anomalies if gold values equal to or greater than 0.3 ppm, lead values equal to or greater than 70 ppm, and silver values equal to or greater than 1 ppm are considered anomalous. Values in the ranges of "high" values shown on plate 3 (3 ppm or more for gold, 200 ppm or more for lead, and 10 ppm or more for silver) should certainly be worthy of further investigation.

In many areas visible concentrations of limonite minerals are a good guide to anomalous amounts of metals, but at Goldfield usefulness of this guide is limited. Qualitative comparison between iron content and relatively intense red (hematite dominant) or yellow-red (goethite dominant) hue (Goddard and others, 1948) indicates that intense color and iron content are definitely well correlated. Unfortunately, iron content is not correlated with gold, lead, silver, bismuth, or mercury content in silicified rocks. (See fig. 7.) Thus, although limonite-rich samples are likely to have larger amounts of arsenic, copper, or molybdenum than limonite-poor samples nearby, they will not necessarily have large amounts of gold, lead, silver, bismuth, or mercury. We expect that a sampling program utilizing limonite-rich altered rocks or limonite scrapings from fractures and analyzing for arsenic, copper, or molybdenum would produce results difficult to interpret. At many localities silicified zones are so numerous that the source of anomalous arsenic, copper, or molybdenum could be hard to find, particularly if the highest values showed up in argillized rocks; detailed sampling for gold would then be required. A better

approach would be to sample silicified rocks selectively, to collect limonite-rich samples wherever they are available, but not ignore silicified zones showing little limonite. The limonite-rich samples could be tested for unusual amounts of arsenic, copper, and molybdenum in addition to gold, lead, and silver. Such samples should be just as likely to show anomalous gold, lead, and silver as limonite-poor silicified rocks. It is questionable that the information gained from making arsenic, copper, and molybdenum analyses in addition to gold, lead, and silver analyses would be worth the cost.

We doubt that soil-sampling surveys would be of much use in the Goldfield altered area. Should such a survey be undertaken in one of the more poorly exposed parts of the area, the anomaly contrast between oxidized silicified and oxidized argillized rocks shown by each geochemical profile indicates the maximum anomaly contrast that might be found, assuming mainly mechanical dispersal of the ore-related elements in colluvium. Lead would be the best indicator in a colluvial-soil survey. Soil-covered parts of the Goldfield altered area appear to be dominantly of colluvial origin although residual soils that are actually soft argillized rocks appear locally.

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