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Statistical parameters for resource evaluation of geochemical data from the Ajo 1° X 2° quadrangle, Arizona

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Abstract

Statistical data are presented from a regional geochemical study of the Ajo 1° X 2° quadrangle exclusive of the Papago Indian Reservation, but including the extension of Organ Pipe Cactus National Monument into the Lukeville 1° X 2° quadrangle. Frequency distribution data from the analysis of stream-sediment and heavy-mineral-concentrate samples for 31 elements have broad ranges and for most elements have maxima well above normal. Elemental associations derived from correlation and R-mode factor analysis related to regional lithologic variation and for some associations suggest mineral-resource potential.

Introduction

The Ajo 1° X 2° quadrangle, excluding the Papago Indian Reservation but including parts of Organ Pipe National Monument in the Lukeville 1° X 2° quadrangle, was sampled during the early spring of 1979 and 1980 as a part of the Conterminous United States Mineral Assessment Program (CUSMAP) of the U.S. Geological Survey. A total of 971 samples of stream sediments, screened to pass a 30-mesh sieve (approximately 0.6 mm), and 952 samples of the nonmagnetic fraction of heavy-mineral concentrates from stream sediment were analyzed by a 31-element optical emission spectrographic method and comprise the basic data set. Details of the sampling and analytical procedures, along with tabulations of the location and analytical procedures have been released in Open-File Report 82-419 (Barton and others, 1982).

The composite data consist of two sets containing 30,101 determinations on the stream sediments, and 29,512 determinations on the heavy-mineral concentrates. In tabular form, it is at best unwieldy. The purpose of this report is to present the summary statistics of various components of these data sets in a variety of ways that present a more concise picture of the data. These statistics form the reduced base on which subsequent interpretations of regional relations among the elements, and between element groups and geology, may be derived. The eventual goal is to improve understanding of the mineral-resource potential of the quadrangle.

The geographic distribution of the samples is presented at a scale of 1:250,000 in plate 1. Only the numerical part of the sample number is used to annotate the sample localities. In the tabular version of the data (Barton and others, 1982), the sample numbers contain an alphabetic prefix that identifies the 15-minute quadrangle containing the locality and an alphabetic suffix that designates the sample type, either stream sediment (SS) or the nonmagnetic fraction of the heavy-mineral concentrate (HN). The numbers are unique to the locality. The samples were collected on minor streams whose drainage basins are either within the mountain ranges, where bedrock is exposed essentially continuously, or whose drainage basins are on pediment surfaces where bedrock is frequently exposed. No attempt was made to sample the major sediment-filled basins; nor were all minor drainages sampled in the mountain ranges. The resultant sample net is uniform and representative, considering the scale, of all parts of the quadrangle where bedrock is near surface.

Summary statistics of the distributions for individual elements

The summary statistics for the frequency distributions for the individual

elements in each of the sample types are presented in tables 1 through 6. From tables 1 and 2, it is seen that six elements were not detected in any of the samples of stream sediment and three elements were not detected in any of the heavy-mineral concentrates. These elements, in the respective sample types, will not be considered further.

Five elements were infrequently detected in the stream sediments and in the heavy-mineral concentrates (tables 3 and 4, respectively). All of these elements are critical to a resource appraisal, representing economically important classes of elements including the base metals (zinc), precious metals (silver), sulfosalt elements (bismuth and antimony), and the oxyphile elements (niobium, tin, and tungsten). Any detectable quantity of these elements is unusual, and the levels obtained for some samples, particularly in the heavy-mineral concentrates, are sufficiently high to suggest that these elements may be locally important components of the mineral systems. Though these elements cannot be treated with classical statistical methods, their associations with other elements will have to be considered in a less formal way.

The remaining elements are present in quantities within the normal analytical range in a sufficient proportion of the samples to allow some form of further statistical analysis. In tables 5 and 6, the elements for each of the sample types have been grouped into three classes based on the percent of the observations within the normal analytical range of detection. In the first group, 87 to 100 percent of the values reported are within the analytical range. The geometric mean and the geometric deviation for these elements are both reliable measures, and further statistical treatment is possible. For the second group of elements, 53 to 86 percent of the values reported are within the analytical range. For these elements, the mean is bracketed with about the same precision as the analytical procedure, but the geometric deviation is an approximation. Further statistical manipulation can yield valuable information for these elements, but is not rigorous. The third group of elements falls within the analytical range in less than 50 percent of the samples. For these, the mean is outside of the analytical range, and a geometric deviation would be meaningless. Further statistical manipulation would have to be by nonparametric method.

The range for all of the individuals in these three groups of elements exceeds an order of magnitude, adequate to suggest some form of systematic regional variation. Ranges in excess of two orders of magnitude are common for the heavy-mineral concentrates. The geometric means are appropriate for the two sample types, but in almost all instances, the maximum value reported is abnormally high for a terrane of common rock types. Some unusual, element-rich terranes occur, contributing to the upper parts of these frequency distributions.

The histograms of figures 1, 2, and 3 show the distributions for the elements in the first three groups for the samples of stream sediment. Because the spectrographic reporting intervals are on a geometric scale, the data has, in effect, been subjected to a logarithmic transformation.

Negatively skewed distributions are evident for the major elements iron, magnesium, and calcium, and for the minor elements titanium, strontium, and zirconium. For most of the minor elements--chromium, copper, lead, yttrium, cobalt, lanthanum, nickel, and scandium--the negative skewness is reflected as a second mode. The major controls over the composition of stream sediments are gross lithologic units that underlie the various drainage basins. As a first

approximation, we assume that the major modes for the distributions illustrated reflect the composition of the dominant lithologic types of the quadrangle. Similarly, the secondary modes on the low side of the principal mode, and much of the negative skewness, most likely reflects subordinate lithologic units poor in these elements.

The extremely low values for strontium, and perhaps barium, obtained at some sites are perhaps an exception to general lithologic controls on the distributions. Though some lithologies such as clean, quartz sandstones may have low values for these elements, the major lithologic units encountered in the Ajo quadrangle should have higher values. Both of these elements, particularly strontium, are lost during hydrothermal alteration. The possibility that the low values reflect alteration should be considered.

Both the magnitude of the high end of the distributions and their shape suggest small areas that are metal rich. Elements included in this category are those detected in few samples--silver, niobium, tin, zinc, thorium, boron, beryllium, and molybdenum as well as lanthanum and nickel among the elements frequently detected, and manganese, barium, chromium, copper, lead, strontium, yttrium, and zirconium among the elements with statistically reliable data. Some of these positive anomalies may reflect unusual lithologic entities, others undoubtedly reflect the superimposition of mineralization upon the host lithologies.

The histograms of figures 4, 5, and 6 show the distributions for the elements in the first three groups for samples of the nonmagnetic fraction of the heavy-mineral concentrates. Like the stream sediments, these distributions reflect, in effect, a logarithmic transformation.

The preparation of this sample type excludes the vast majority of the common rock-forming minerals. Quartz, feldspar, and most of the carbonates are removed by the gravity separation and most of the ferromagnesian minerals are removed by the magnetic separation. Removed also are those minor elements incorporated in some way in the rock-forming minerals. As a result, the distributions displayed here do not reflect the gross aspect of the lithologies. The patterns reflect either accessory minerals in the major lithologic units or accumulations of exotic minerals from lithologies that need not constitute a large proportion of the drainage basin contributing to the sample.

The titanium and zirconium distributions illustrate the accessory mineral contribution. Zircon is a common, minor accessory mineral in most of the major rock types. The small contribution of zircon from the large mass of rock is sufficient to shift the mode for zirconium out of the normal range of the analytical technique at the high end. Only in areas of rocks extremely poor in zircon or in areas where some other heavy, nonmagnetic accessory mineral is extremely abundant do the zirconium values drop back into the analytical range. The abundance of sphene or rutile as accessory minerals, even in rocks where the principal host for titanium is ilmenite or one of the ferromagnesian minerals, has the same effect on the titanium distribution. These minerals, along with apatite, which accounts for the high levels for calcium and probably also the high background for yttrium and lanthanum, constitute the continuum against which the other minerals and their chemical components are measured in this sample type.

Barium provides an example of the "exotic" mineral control on elemental

distribution in the heavy-mineral concentrates. The principal mode for barium, and the minimum, are well below those for the stream sediments, reflecting the removal of most of the potassium-rich minerals of low-specific gravity that host the majority of the barium in the country rocks. The long tail of the distribution for barium in the heavy-mineral concentrates extends well beyond the maxima for the stream sediments to an upper mode where barium is a major component of the sample. These barium-rich samples contain barite, which is most likely derived from veins that are volumetrically insignificant relative to the country rocks.

These characteristics of the heavy-mineral concentrates lead to broad distributions of low kurtosis. The range of values for many of the elements spans the entire range of the analytical procedure. Multimodal distributions are common, reflecting subtle shifts in the abundance or nature of the minerals hosting the elements. Skewed distributions, often ranging to extremely high values, are common. The advantage of this sample type for spreading the distributions and highlighting anomalous areas is obvious. Caution must be used in interpreting the data, however, because the high values obtained from concentrates may not have direct economic significance; they indicate potential rather than ore.

The mineralogic host for some of the elements in their areas of maximum concentration are known. Barite has been mentioned as the prime source for the extreme values in barium; it also accounts for at least part of the extreme values for strontium. The maxima for chromium, cobalt, and nickel are associated with an abundant weakly magnetic chrome diopside derived from some of the volcanic terranes and also from spinels. Apatite appears to provide the principal mode for lanthanum and yttrium, whereas monazite and xenotime contribute to the extreme values. Wulfenite contributes to the maxima for lead and molybdenum, though other hosts for these elements are also required and have not been identified. Chrysocolla is the predominant secondary copper mineral, though malachite, azurite, and a variety of other secondary copper minerals have been seen in the concentrates. A considerable part of the copper must also be incorporated in secondary iron and manganese oxides. Cassiterite is the predominant tin mineral. In addition to monazite, thorite contributes to the thorium maxima.

Elements infrequently detected in either the stream sediments or the heavy-mineral concentrates (tables 3 and 4) are not represented in the histograms. Samples in which these elements were detected are listed in tables 7 through 15, where they are grouped with data for associated elements to facilitate the discussion to follow.

Relations among the elements

The Ajo quadrangle is sufficiently large and sufficiently diverse geologically to allow the speculation that a large fraction of the variation for the elements reflects regional variation in gross lithologies and in the surficial environment. The relations among the elements allow a test of this speculation and provide a basis for sorting variation beyond that attributable to overall environmental factors. This latter variation is related to smaller, or more subtle features such as mineral deposits. In addition, relations among the elements provide another mechanism for sorting the mass of data into a smaller number of geochemically coherent entities, removing, for example, the redundancy inherent in interpretation of individual elements that are closely related in nature.

Infrequently detected elements

Elements detected in few samples (tables 3 and 4) are not suited to further mathematical analysis and are presented in tables 7-15. In tables 7-15, data for a group of elements that could be expected to relate to the infrequently detected element are presented for comparison, and a considerable insight into possible associations among the elements can be obtained simply by examination of the raw data. The single sample of stream sediment in which zinc was detected, table 7, also is rich in copper and lead, suggesting a base-metal enrichment. The two sites rich in silver in the stream sediments are not rich in the base metals, though one of the two is enriched in molybdenum.

Considerably more information on potential base metals, indicated by the elements infrequently detected, is gained from the heavy-mineral concentrates. The highest detected zinc, table 8, is at the same site as the zinc-rich stream sediment and it again contains above average copper and lead. A second, nearby site is also zinc rich. The third zinc-rich heavy-mineral concentrate is also molybdenum rich and is in a cluster of samples rich in silver, copper, molybdenum, lead, and antimony. All but one of the silver-rich, heavy-mineral concentrates (table 9) are in this cluster as are three of the six antimony-rich samples (table 10). A silver-rich, base-metal, sulfosalt assemblage is strongly in evidence in this area. The other silver-rich sample is also rich in copper, molybdenum, and lead. It is from an area suspected to be mineralized for other reasons. Likewise, the three other samples with detectable antimony, which also contain above average copper and(or) lead, are in areas suspected for other reasons to contain mineralization. It appears, therefore, that all of the samples containing these rarely detected elements of the base, precious, and sulfosalt assemblages are from areas of mineralization.

Bismuth is sometimes associated with the sulfosalt assemblage of elements, but in the Ajo quadrangle, none of the sites described above are among those in which bismuth was detected in the heavy-mineral concentrates (table 11). Instead, the bismuth appears to have a more direct association with lead and to a lesser extent tungsten. Of the 45 sites where bismuth was detected, 27 contain more than 200 ppm of lead and 17 contain detectable tungsten. Because only 5 percent of the samples contain detectable bismuth and only 7 percent contain detectable tungsten, this 40-percent overlap appears significant. Furthermore, 12 of the 17 samples enriched in both bismuth and tungsten contain more than 200 ppm of lead. A strong, three-way association appears to exist among bismuth, tungsten, and lead.

No association of bismuth with either tin or molybdenum is apparent. Only eight of the bismuth-rich samples contain 100 ppm or more of tin, more or less in line with the 18 percent of the samples from that entire quadrangle that contain 100 ppm or more of tin. Only four, less than 10 percent, of the bismuth-rich samples contain 20 ppm or more of molybdenum, in contrast with the entire quadrangle where 15 percent of the samples contain 20 ppm or more of molybdenum. Furthermore, 60 percent of the bismuth-rich samples contain less than 10 ppm of molybdenum, whereas the comparable figure for the entire quadrangle is less than 50 percent. If anything, the bismuth-rich samples have less than normal molybdenum. This result is somewhat surprising inasmuch as a significant association of lead and molybdenum occurs on a quadrangle-wide base, as will be discussed later.

Samples of the heavy-mineral concentrates with detectable tungsten are

presented in table 12 with the same suite of elements considered with bismuth. No association with tin is apparent. Though the 11 percent of the samples rich in both tungsten and tin is below the quadrangle-wide average of 18 percent for tin-rich samples, the remainder of the tin values have frequencies similar to those of the quadrangle-wide average. In other words, the tin content of the tungsten-rich samples is about normal but includes fewer than expected tin-rich samples.

The tungsten-rich samples are frequently rich in lead, molybdenum, and, as noted above, bismuth. At least 50 percent of the tungsten-rich samples contain 20 ppm or more of molybdenum and(or) 200 ppm or more of lead. As described above, most of the samples rich in both tungsten and bismuth are also rich in lead and are usually poor in molybdenum. Similarly, two-thirds of the samples rich in both tungsten and molybdenum are also rich in lead and usually poor in bismuth. In addition to the three binary associations of tungsten with bismuth, molybdenum or lead, two mutually exclusive ternary associations are apparent; one of tungsten-bismuth-lead and the other of tungsten-molybdenum-lead. These assemblages do not match previously known mineral deposits of the area. They are not assemblages to be expected from the major lithologic units of this area. These are sufficiently strong associations, with sufficiently high levels of elemental concentration, to suggest a new type mineral potential for the area.

Three of the elements usually concentrated in felsic rocks, niobium, tin, and thorium are only infrequently detected in the stream-sediment samples. Niobium was 20 ppm or more in only 29 samples, table 13. These samples are significantly richer than normal for the Ajo quadrangle in yttrium, zirconium, beryllium, titanium, and probably lanthanum. The two samples with detectable tin (table 14) are similarly enriched in this felsic assemblage. Thorium, detected in only three samples of the stream sediment (table 15), follows a different pattern of association, favoring either vanadium or lanthanum, but not particularly associated with the other components of the felsic assemblage. These elements in the stream sediments are evidently contained in heavy, nonmagnetic minerals that persist into and are greatly enhanced in the heavy-mineral concentrates. The correlations noted here are much more vividly displayed in the heavy-mineral concentrates in which the data are sufficient to establish much more clearly the elemental and geologic relations for these elements.

Frequently detected elements

The majority of the elements sought in the two sample media were detected with sufficient frequency to allow more rigorous analysis of element associations. For elements in groups I and II of tables 5 and 6, binary relations among the elements can be examined via correlation coefficients. Figure 7 presents the matrix of correlation coefficients for 17 elements in the stream sediments and figure 8 presents the matrix of correlation coefficients for 18 elements in the nonmagnetic heavy-mineral concentrates. To facilitate computation of these coefficients, indeterminate codes N, L, and G have been replaced by constants. L is given a value two reporting steps below the lower limit of detection and N is given a value one reporting step below the value assigned to L. G is given a value two reporting steps above the upper limit of detection. For the elements included in figures 7 and 8, these arbitrary replacements are reasonable, and the effect of replacement on the numerical value of the coefficients is negligible.

Correlations for elements with severely truncated distributions (group III of tables 5 and 6) have been computed in the same way and are presented in figures 9 and 10. For these elements, the effect of the arbitrary replacement of the indeterminate codes on the numerical value of the correlation coefficients may be pronounced. In most instances, the numerical value of the coefficient is reduced by the arbitrary spread of values along a horizontal or vertical boundary near the limit of detection. In instances where the distributions for both elements are severely truncated in the same direction, the apparent coefficient may be enhanced. This may be the case for the triplicate titanium-zirconium-yttrium in the heavy-mineral concentrates, all of which are truncated at the upper limit of detection. Examination of the coefficients for the triplicate boron-beryllium-molybdenum in the stream sediments, all of which are truncated at the lower limit of detection, indicates that the amount of distortion is not great. In any event, the correlation coefficients for these truncated elements provide as a minimum a measure of the tendency for association among the element pairs.

The correlation matrices for elements in groups I and II, figures 7 and 8, are suitable for entry into R-mode factor analysis. The results of such analyses are presented in figures 11 through 14 in a manner intended solely to identify the composition of groups of related elements. Figures 11 and 12 are derived from the USGS STATPAC system program D0096 (VanTrump and Miesch, 1977) and display the reordered oblique projection matrix for rotations of 2 through 10 factors. This method of presentation provides a simple display of the gross relations of elements to the factors, and allows a comparison of changes of the factors as the number of factors is increased. For figures 13 and 14, the ER-mode (a variant of the conventional STATPAC program designed by A. T. Miesch) is used. In figures 13 and 14, the composition of eight factors is displayed via the correlation of the elements with the varimax scores for the factors.

The grouping of the elements used in the correlation matrices (figs. 7 and 8) are based on the 6-factor solution for the stream sediments and on the 5-factor solution for the heavy-mineral concentrates (figs. 11 and 12). These models were arbitrarily chosen by the authors as those best representing the most important element groups. The combination of these three methods of displaying interelement associations, the correlation matrix, and the two variants on factor analysis can be used to explain the causes for the greater part of the variance in the data. All three approaches yield similar results that are geologically reasonable.

The dominant factor in both sample media is the assemblage of elements commonly referred to as the ferride elements (Landergren, 1943), the elements commonly enriched in mafic rocks or ferromagnesian minerals. The dominant control for this assemblage is gross lithologic variation. Copper, an element important to a mineral-resource evaluation in this geologic environment, is clearly a member of the ferride assemblage. In the stream sediments, it is not until the seventh factor (fig. 11), less than five percent of the total variance, that copper parts company with the ferride assemblage and forms a factor essentially on its own. In the heavy-mineral concentrates, this does not happen until the ninth factor (fig. 12), again accounting for less than five percent of the total variance. In order to properly interpret the copper distribution in terms of mineral-resource potential, it will be necessary to separate its variation that is related to that of the ferride assemblage from its variation that is independent of the ferride assemblage.

The influence of carbonate rocks is seen in the stream sediments only; the major minerals of the carbonate environment are mechanically excluded from the heavy-mineral concentrates. In the stream sediments, the carbonate environment is reflected by two factors. Factor 3 in both the ER-mode (fig. 13) and the sequential display (fig. 11) is dominated by strontium and barium, but includes calcium as a major component and to a lesser extent magnesium. Farther down the sequence, factor 6 in the ER-mode (fig. 13), but first appearing in the 8-factor rotation of the sequential display (fig. 11), is a calcium-magnesium factor. The first of these factors most likely reflects the partition of strontium between the carbonate rocks and barite. The second of these is negatively associated with barium, clearly antibarite, procarbonate. As barite is a common associate of base-metal deposits, and because barite has been mined in the area, it would seem possible to sort the barium and strontium on a basis of nonassociation with calcium and magnesium to get a stronger barite factor stripped of gross lithologic controls. This is not necessary because, as noted above, the common carbonate minerals are excluded from the heavy-mineral concentrates. In the concentrates, the strong barium-strontium factor appears as factor 3 and is essentially unrelated to calcium and magnesium. Barite is the obvious control for this factor, whereas magnesium remains solidly associated with the ferride assemblage and calcium forms an independent factor (number 4) clearly associated with the abundance of apatite.

Vanadium is normally a ferride element, and in the correlation matrices of figures 7 and 8, a large correlation coefficient exists between vanadium and all of the other ferride elements in both sample media. On the basis of the ER-mode factor analysis, vanadium is a significant component of factor 1, the ferride factor, in both sample media (figs. 13 and 14). However, factor 2 is more heavily dependent on vanadium than factor 1. In the illustration of the sequence of element associations in the heavy-mineral concentrates (fig. 12), vanadium is a consistent member of the ferride assemblage through the rotation of the first seven factors, whereupon it becomes an independent entity, associated, if at all, with niobium (factor 2 of the ER-mode). Niobium is the strongest negative associate of the ferride assemblage. This pattern would be far more complex had the data for the truncated distributions (fig. 10) been included in the factor analysis. Vanadium correlates well with titanium and thorium. In the illustration of sequential factor analysis for the stream sediments (fig. 11), vanadium is best described as a vagrant. Its most consistent association would be with iron, titanium, and zirconium, as in factor 2 of the ER-mode (fig. 13). This association suggests a surficial control, vanadium in detrital iron oxides accumulating as placers.

Vanadium appears to be responding to at least three geologic controls. The dominant controls are gross lithologic variations wherein vanadium rides along as a member of the ferride assemblage, and geomorphic variations wherein vanadium rides along with placer accumulations of detrital iron oxides. A third control, related in some way to felsic components of the system, particularly niobium and thorium, may have connotations of mineral-resource potential. Factor 2 of the ER-mode for the heavy-mineral concentrates seems to offer the only potential for sorting out that part of the vanadium distribution of primary interest.

Manganese and iron, often associated with the ferride assemblage, are relatively independent entities in this data. Iron in the stream sediments is more closely associated with titanium than with manganese. This association and that of titanium with zirconium yields factor 2 of figure 13, implicating

placer accumulation of magnetite, ilmenite, and zircon as the primary control to its distribution. In the heavy-mineral concentrates, these iron minerals are excluded and iron becomes a subordinate member of a manganese-iron assemblage (factor 7 of fig. 14). In this environment, the predominate control for manganese distribution is expected to be the regional geomorphic control on the amount of desert varnish, that is, the surficial accumulation of manganese and iron oxides. Though manganese may have a secondary association with hydrothermal mineral deposits, no statistical way apparently exists of identifying such an association independently from other more direct evidence of mineralization.

The heavy-accessory minerals of the major lithologic units, and their accumulation in placer deposits, appear to account for a large part of the interelement associations. Relations of this type are inherent to the heavy-mineral concentrates, but in these samples remarkably similar relations are present in the stream sediments. Though the principal control for these associations appears to be gross lithology and geomorphic history, several of the element associations, and the suspected mineral hosts, have resource potential in placers, and unusual accumulations of these minerals in lodes cannot be ruled out.

Titanium concentration levels in the stream sediments are commonly in the range of one percent or more. Providing suitable mineralogy, this is sufficiently high to allow a resource potential. As noted earlier, the association of titanium with iron and vanadium in the stream sediments (factor 2 of fig. 13), suggests the occurrence of iron-titanium oxides, which are of little resource potential. The consistent strong relation of titanium and zirconium provides evidence for a different mineralogic association more closely allied with the felsic rocks. In the nonmagnetic fraction of heavy-mineral concentrates the association of titanium (fig. 10) is again with zirconium, and with yttrium, and to a lesser extent niobium. Because the iron-titanium oxides are magnetically excluded from this sample, sphene or rutile could be suspected, the latter in particular, where the association with niobium is strongest. An attempt to sort the titanium according to its association with these components could provide resource information.

The consistent association of lanthanum and yttrium in the stream sediments (factor 5 of fig. 13), and particularly the late appearance of a yttrium-scandium assemblage separate from lanthanum (the 9- and 10-factor models of fig. 11), implicate monazite and xenotime as the source minerals. Levels are sufficiently high to suggest some resource potential. The association is confirmed in the heavy-mineral concentrates (fig. 10), where additional components of the association include titanium and niobium. Surprisingly, thorium is only weakly associated with lanthanum and is not associated with yttrium. Evidently the thorium in monazite is not sufficient to overcome the thorium-vanadium association, and the two assemblages involving thorium must be spacially distinct.

Tin was only detected in two of the stream sediments, but its frequency and magnitude in the concentrates warrants consideration. Cassiterite is expected and has been identified in the concentrates. The tin is associated with niobium (factor 8 of fig. 14) and to a lesser extent with lanthanum (fig. 8).

Lead is the only element of this suite that appears as a direct,

mineralization-related factor in the stream sediments (factor 4, fig. 13). In the concentrates, an assemblage with molybdenum is indicated (factor 5 of fig. 14). The same assemblage is probable in the stream sediments (fig. 9). As noted in the discussion of the infrequently detected elements, a lead-bismuth assemblage occurs that appears to be incompatible with the lead-molybdenum assemblage, and tungsten is often associated with either of these assemblages. Wulfenite is the obvious candidate for the lead-molybdenum assemblage in this environment. In areas where tungsten is a component of the assemblage, a scheelite-powellite-stolzite association is possible. A secondary association of lead with felsic elements exists in the stream sediments, but the primary control for both lead and molybdenum appears to be mineralization related.

Summary

Most of the elements detected in samples of stream sediment and nonmagnetic heavy-mineral concentrates from the Ajo quadrangle were found to have sufficient range and to reach sufficient levels of concentration to suggest major regional variations that could be related to resource potential. Much of this variation can best be related to regional variations in gross lithology or to more recent geomorphic features. However, little evidence occurs in these samples for modification of the area's chemistry by 40 years of use of the area as a test and training site for military ordinance. The following elements, element assemblages, or parts of element distributions seem likely to relate to mineral-resource potential:

1. Lead and molybdenum in both sample media, particularly in sites of overlap of these two elements.

2. Bismuth and tungsten in the heavy-mineral concentrates, particularly in sites of overlap of these two elements and of overlap with lead and(or) molybdenum.

3. Copper when normalized against the ferride elements to minimize variation related to gross lithologic variations in both sample media.

4. The rare occurrences of detectable zinc, silver, or antimony in either sample media.

5. Barium and strontium in the heavy-mineral concentrates where barite is expected to be the dominant control for high values, and in stream sediments where unusually low values may reflect hydrothermal alteration.

6. Manganese where other evidence can support the assumption that this element is related to mineralization rather than desert varnish.

7. Tin in the heavy-mineral concentrates, particularly in sites of overlap of tin with niobium or lanthanum.

8. Lanthanum and yttrium in either sample media, though the stream sediments may be preferred to avoid the truncation of the yttrium distribution at the upper limit of detection in the heavy-mineral concentrates.

9. Thorium in the heavy-mineral concentrates, particularly in sites where thorium, vanadium, and niobium are related (factor 2) in contrast to sites where thorium and lanthanum are related (monazite).

10. Titanium in the stream sediments where rutile can be suspected as the host mineral. The most likely geochemical criteria for this condition will be high titanium with high zirconium and niobium and low yttrium and ferrides. Sites then identified can be verified mineralogically in the heavy-mineral concentrations.

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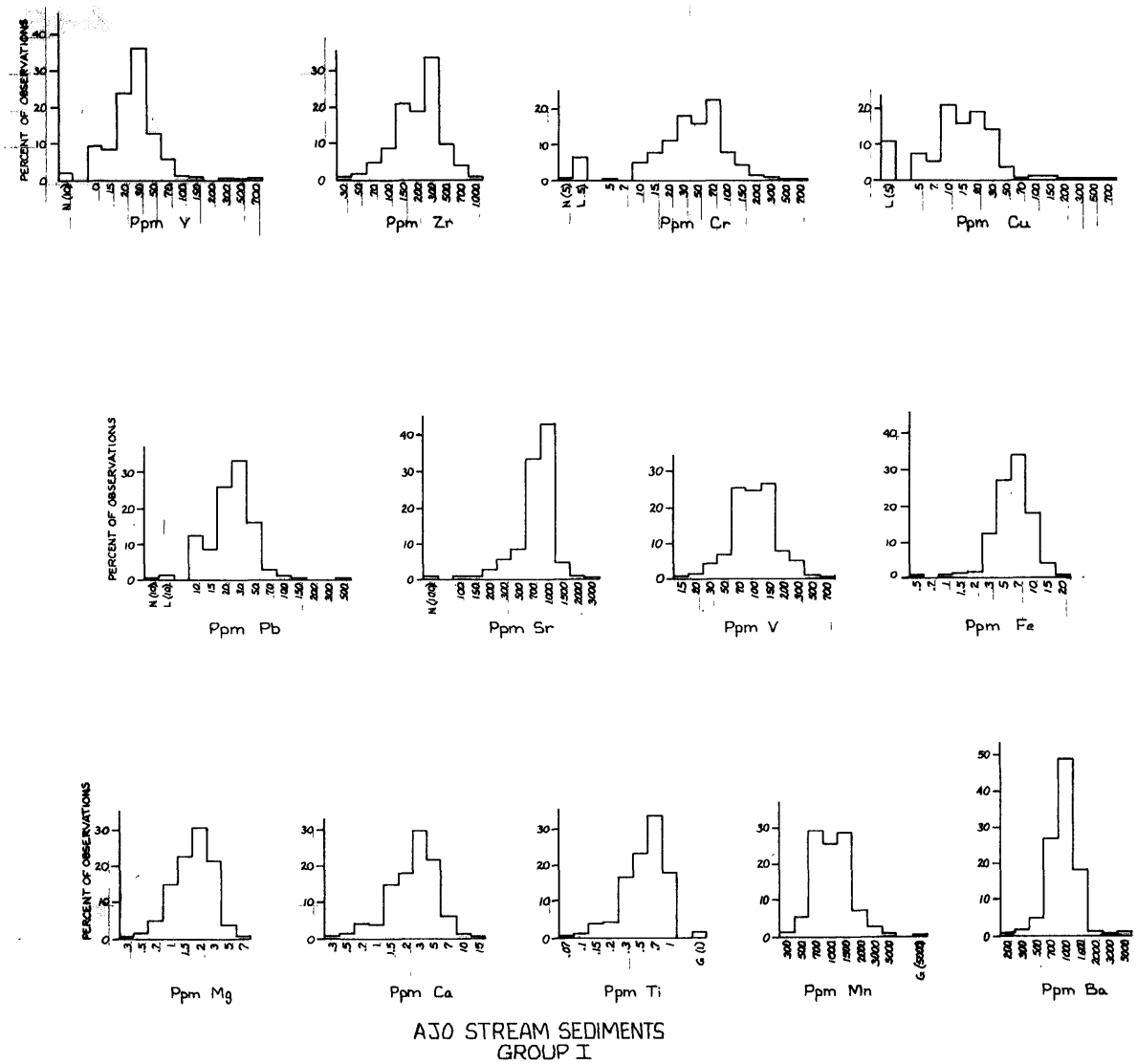


Figure 1.--Histograms showing the distributions for elements detected in a sufficient proportion of 30-mesh, stream-sediment samples from the Ajo quadrangle to provide a reliable measure of the geometric mean and geometric deviation. Frequencies are shown as a percentage of the 971 samples of this type for each of the spectrographic reporting intervals.

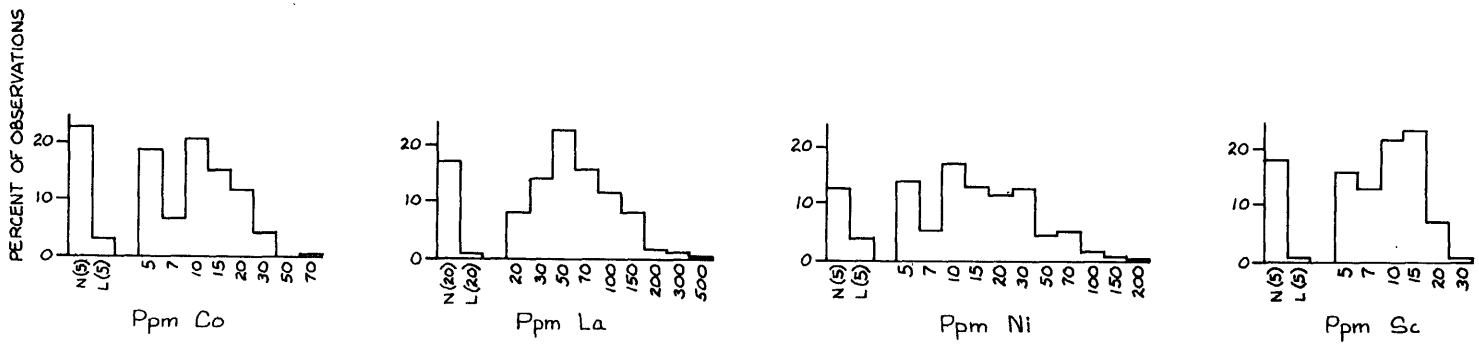


Figure 2.--Histograms showing the distributions for elements detected in a sufficient proportion of 30-mesh, stream-sediment samples from the Ajo quadrangle to provide a reasonable estimate of the geometric mean and a minimum estimate of the geometric deviation. Frequencies are shown as a percentage of the 971 samples of this type for each of the spectrographic reporting intervals.

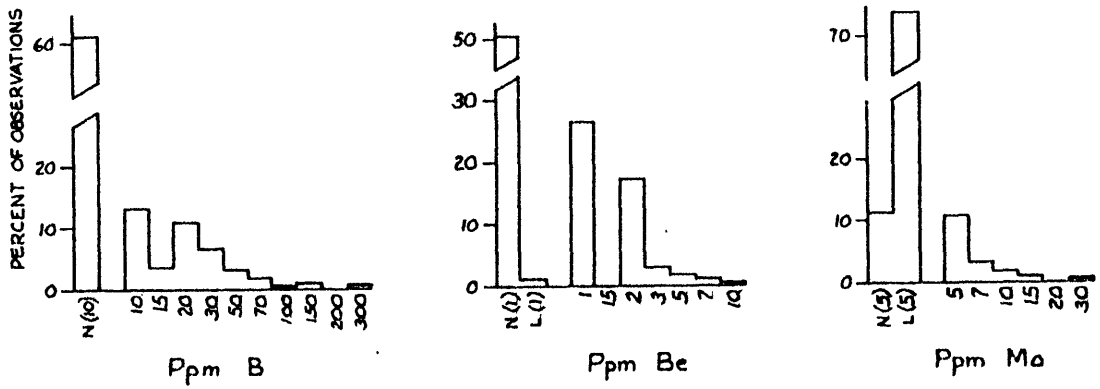


Figure 3.--Histograms showing the distributions for elements detected in a significant proportion of 30-mesh, stream-sediment samples from the Ajo quadrangle, but with insufficient frequency to allow estimation of the geometric mean. Frequencies are shown as a percentage of the 971 samples of this type for each of the spectrographic reporting intervals.

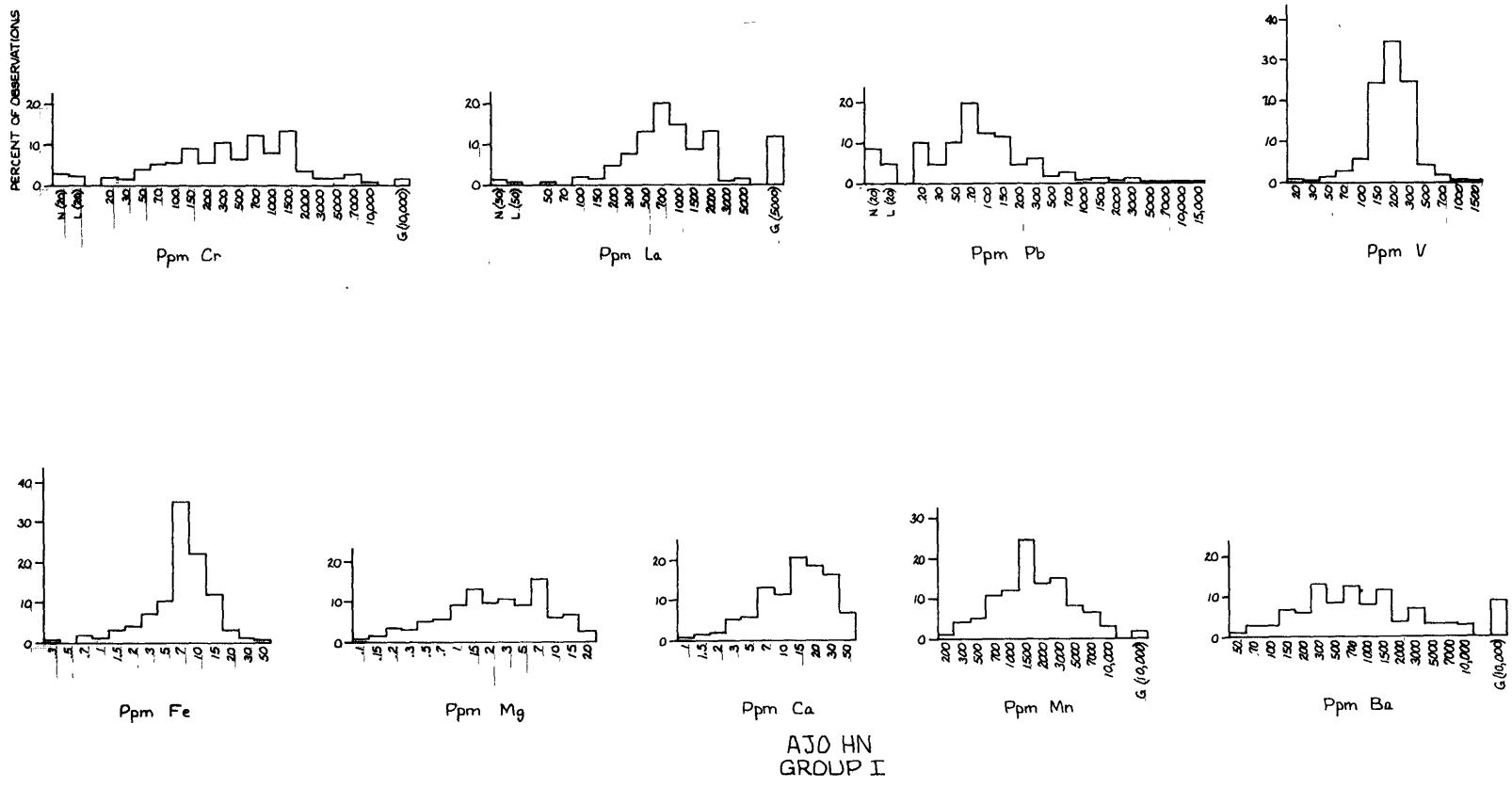
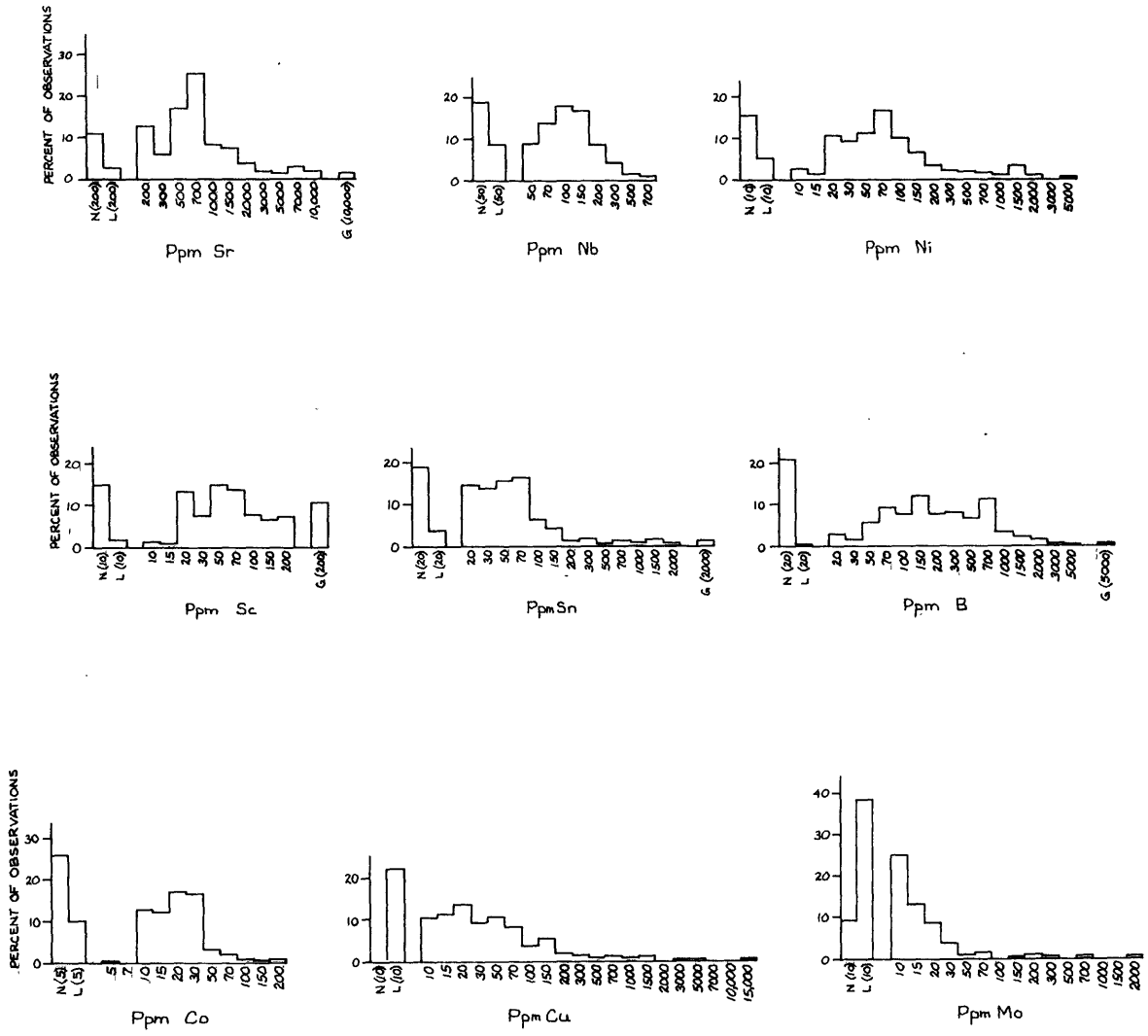


Figure 4.--Histograms showing the distributions for elements detected in a sufficient proportion of the nonmagnetic fraction of heavy-mineral concentrates from stream sediment from the Ajo quadrangle to provide a reliable measure of the geometric mean and the geometric deviation. Frequencies are shown as a percentage of the 952 samples of this type for each of the spectrographic reporting intervals.



AJO HN
GROUP II

Figure 5.--Histograms showing the distributions for elements detected in a sufficient proportion of the nonmagnetic fraction of heavy-mineral concentrates from stream sediment from the Ajo quadrangle to provide a reasonable estimate of the geometric mean and a minimum estimate of the geometric deviation. Frequencies are shown as a percentage of the 952 samples of this type for each of the spectrographic reporting intervals.

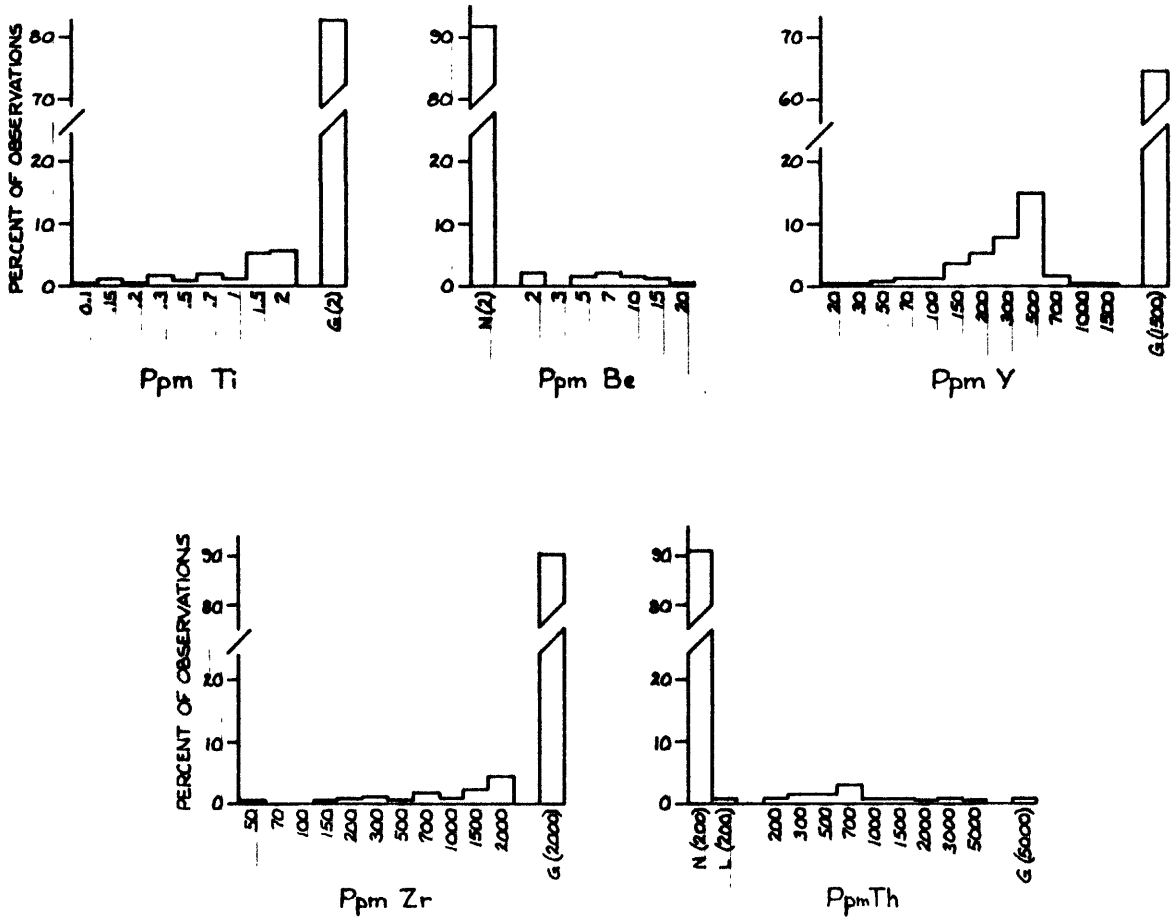


Figure 6.--Histograms showing distributions for elements detected in a significant proportion of the nonmagnetic fraction of heavy-mineral concentrates from stream sediments from the Ajo quadrangle, but with insufficient frequency to allow estimation of the geometric mean. Frequencies are shown as a percentage of the 952 samples of this type for each of the spectrographic reporting intervals.

	Ni	Cr	Co	Sc	Mg	Cu	Mn	V	Ba	Sr	Ca	La	Y	Zr	Ti	Fe	
Pb	-.13	-.13	-.15	-.06	.01	.09	.23	-.06	.18	.15	-.05	.25	.25	.24	.12	.03	Lead
Fe	.24	.34	.37	.47	.45	.33	.52	.67	.24	.39	.34	.11	.30	.50	.71		
Ti	.20	.31	.34	.47	.44	.38	.55	.66	.33	.46	.36	.13	.34	.60			
Zr	-.03	.06	.00	.23	.25	.26	.35	.35	.23	.39	.19	.26	.39				Felsic
Y	-.07	.04	.08	.27	.01	.14	.36	.18	-.05	.01	-.11	.45					
La	-.25	-.22	-.15	-.06	-.09	-.02	.10	-.04	.09	.07	-.08						Rare Earth
Ca	.34	.34	.32	.39	.61	.28	.25	.35	.44	.56							
Sr	.02	.08	.02	.18	.44	.15	.20	.25	.64								Carbonate Sulfate
Ba	.03	.08	.08	.12	.32	.18	.24	.21									
V	.46	.56	.61	.55	.40	.49	.53										
Mn	.22	.29	.36	.44	.34	.33											Mixed Ferride-Felsic
Cu	.46	.46	.53	.47	.40												
Mg	.52	.54	.45	.56													
Sc	.60	.64	.65														
Co	.72	.69															Ferride
Cr	.78																

Figure 7.--Correlation matrix among 17 elements in 971 samples of 30-mesh stream sediment from the Ajo quadrangle. The arrangement of the elements conforms to the groupings derived from a 6-factor model.

	Co	Sc	Ni	Fe	Mg	Cu	Cr	V	Nb	La	Sn	B	Mn	Sr	Ba	Mo	Pb	
Ca	-.06	-.01	-.01	.09	.14	.04	.18	.14	.03	.17	.10	-.05	.00	.25	-.13	.05	-.20	Apatite?
Pb	.00	.05	-.04	.02	-.21	.22	-.16	.06	.07	.30	.11	.22	.08	.03	.18	.24		
Mo	-.12	-.28	-.12	-.16	-.20	-.04	-.20	.03	.04	-.01	.07	-.20	-.15	-.04	-.02			Wulfenite
Ba	.11	.08	.02	.12	.11	.08	.06	.06	.03	.01	-.06	.23	.16	.45				
Sr	.01	-.01	-.07	.05	.06	.17	.08	-.06	.02	.15	.04	.18	.08					Barite
Mn	.38	.37	.18	.58	.40	.24	.22	.17	.21	.23	.17	.28						
B	.20	.50	.32	.38	.27	.43	.31	.29	.22	.35	.12							
Sn	-.11	.01	-.09	.10	-.06	.09	-.04	.05	.40	.24								Felsic
La	-.10	.14	-.02	.11	-.11	.20	-.09	.04	.33									
Nb	-.25	-.02	-.17	.17	-.15	.02	-.19	.14										
V	.43	.39	.37	.50	.36	.37	.34											
Cr	.63	.59	.62	.48	.80	.31												
Cu	.43	.40	.37	.40	.31													
Mg	.71	.58	.60	.59														
Fe	.59	.51	.37															Ferride
Ni	.61	.67																
Sc	.55																	

Figure 8.--Correlation matrix among 18 elements in 952 samples of the nonmagnetic fraction of heavy-mineral concentrates from stream sediment from the Ajo quadrangle. The arrangement of the elements conforms to the groupings derived from a 5-factor model.

	Ni	Cr	Co	Sc	Mg	Cu	Mn	V	Ba	Sr	Ca	La	Y	Zr	Ti	Fe	Pb	Mo	Be
B	.06	.03	.03	-.10	-.11	.00	-.09	-.07	-.13	-.26	-.17	-.08	-.05	-.13	-.21	-.18	.01	.24	-.08
Be	-.14	-.13	-.12	.08	-.08	-.05	.09	-.09	-.05	.02	-.10	.08	.16	.06	.04	.00	.13	-.02	
Mo	-.02	-.05	-.01	-.12	-.13	-.02	-.09	-.10	-.01	-.12	-.12	-.05	-.06	-.17	-.20	-.24	.23		

Figure 9.--Correlation matrix for 3 elements whose level of concentration is at or below the limit of detection in more than 50 percent of the 971 samples of 30-mesh stream sediment from the Ajo quadrangle. These correlations are not rigorous, are most likely a minimum value, because values of "less than" and "not detected" have arbitrarily been set at a constant equal to a value two and three reporting steps below the limit of detection in order to facilitate computation.

	Co	Sc	Ni	Fe	Mg	Cu	Cr	V	Nb	La	Sn	B	Mn	Sr	Ba	Mo	Pb	Ca	Th	Zr	Y	Be
Ti	.03	.20	.05	.28	.02	.05	-.07	.22	.30	.20	.00	.20	.23	.06	.09	-.07	-.01	-.01	.00	.56	.55	.10
Be	.07	.16	-.03	.22	-.04	.00	-.04	.00	.21	.16	.20	.12	.36	-.01	.00	-.01	.06	-.16	.09	.04	.15	
Y	-.15	.24	.07	.13	-.20	.07	-.21	.07	.36	.44	.05	.18	.14	.04	.01	-.05	.01	.10	-.01	.31		
Zr	.03	.20	.08	.16	.10	.03	.05	.14	.15	.11	.03	.11	.11	.00	.06	-.01	.01	.02	.03			
Th	-.02	-.07	-.03	-.11	-.12	-.01	-.07	.25	.01	.11	-.03	-.04	-.06	.00	.08	.19	.21	-.06				

Figure 10.--Correlation matrix for 5 elements whose level of concentration is either above or below the limits of detection in more than 50 percent of the 952 samples of the nonmagnetic fraction of heavy-mineral concentrates from stream sediment from the Ajo quadrangle. These correlations are not rigorous, are most likely a minimum value, because values of "less than", "not detected", and "greater than" have arbitrarily been set at a constant equal to a value two and three reporting steps below the lower limit of detection or two reporting steps above the upper limit of detection in order to facilitate computation.

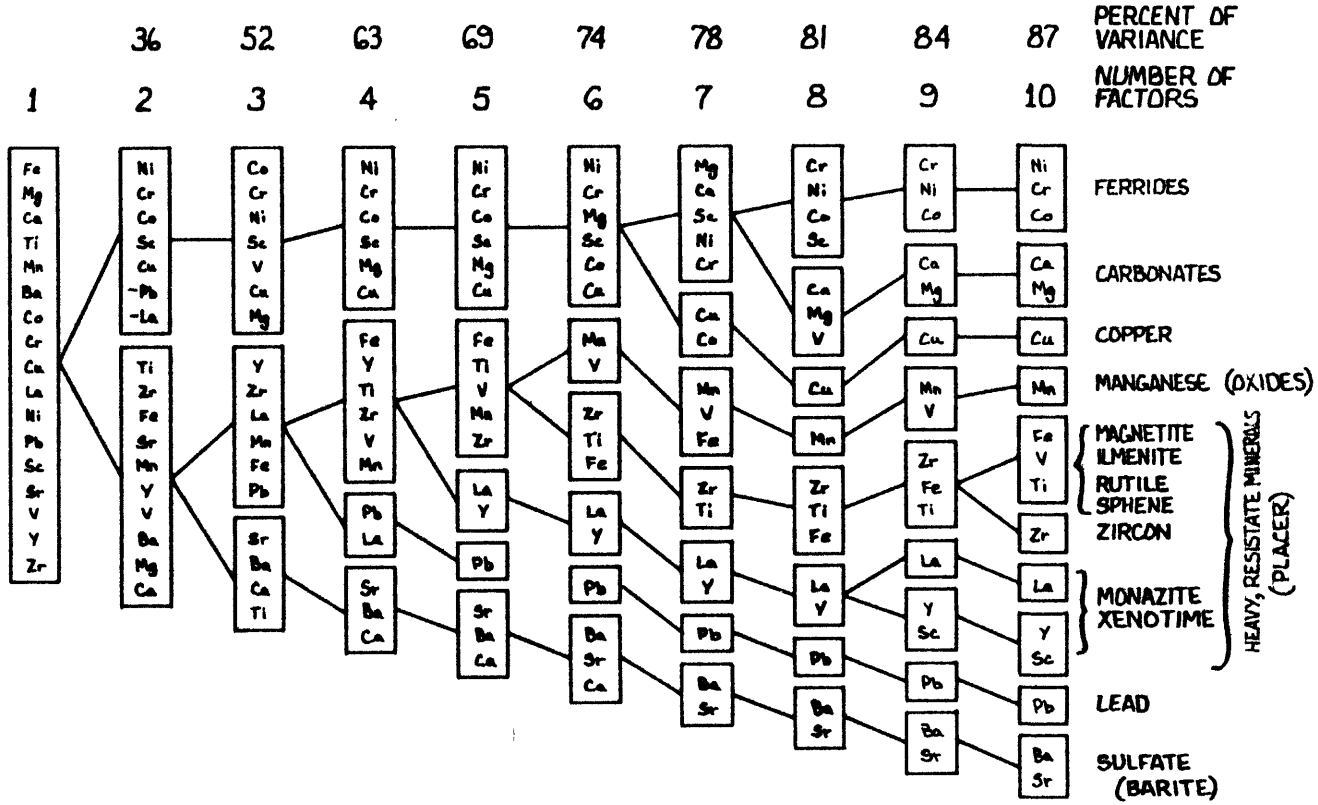


Figure 11.--Groupings of 17 elements in 30-mesh stream sediment elements defined by the reordered oblique projection matrix of R-mode factor analysis rotated sequentially through 2 to 10 factors for from the Ajo quadrangle. Possible geologic interpretations for factors are identified to the right.

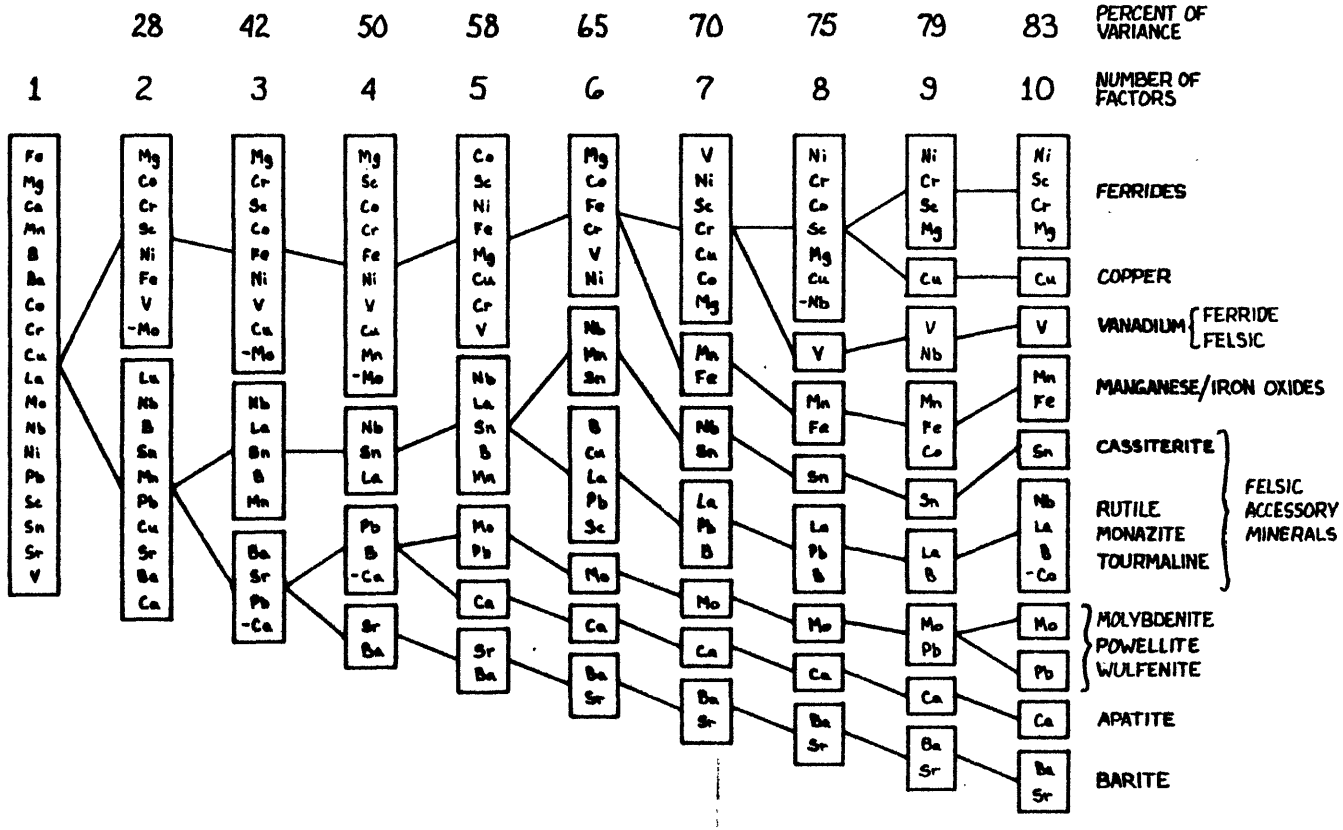


Figure 12.--Groupings of 18 elements in the nonmagnetic fraction of heavy-mineral concentrates from stream sediment defined by the reordered oblique projection matrix of R-mode factor analysis rotated sequentially through 2 to 10 factors from the Ajo quadrangle. Possible geologic correlatives for factors, are identified to the right.

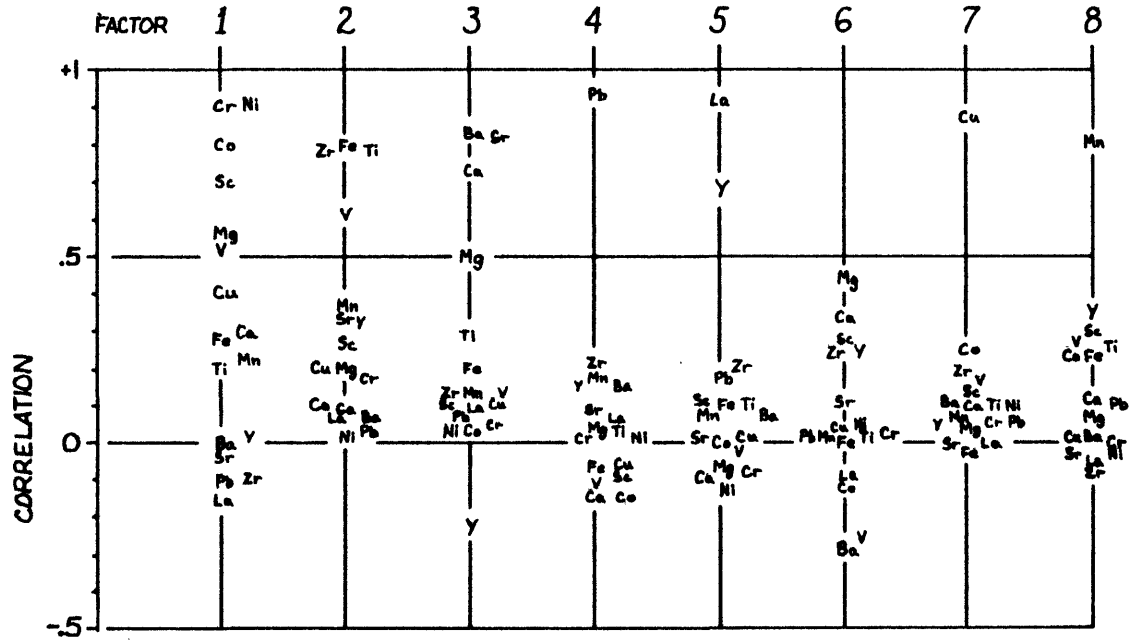


Figure 13.--Relationships among the elements in the first eight factors of a ten-factor rotation as measured by the loading of the elements with the varimax scores from R-mode factor analysis for 17 elements in 30-mesh stream sediment from the Ajo quadrangle.

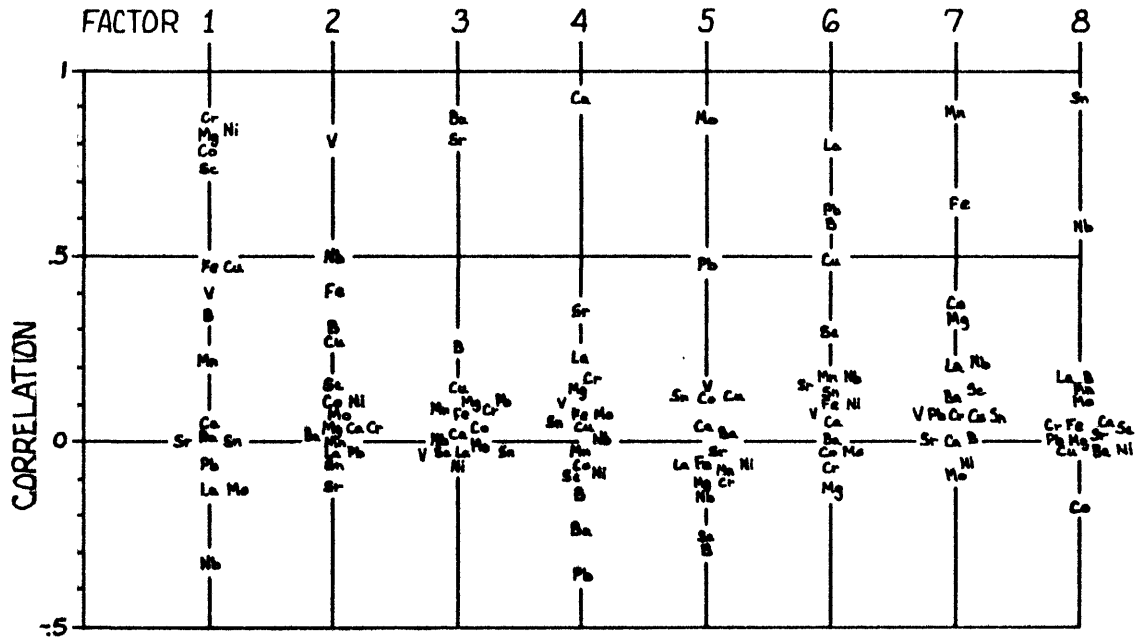


Figure 14.--Relationships among the elements in the first eight factors of a ten-factor rotation as measured by the loading of the elements with the varimax scores from R-mode factor analysis for 17 elements in the nonmagnetic fraction of heavy-mineral concentrates from stream sediment from the Ajo quadrangle.

Table 1.--Elements sought but not found in samples of minus-30-mesh stream sediment from the Ajo quadrangle, Arizona

Element	Limit of detection (parts per million)
As	200
Au	10
Bi	10
Cd	20
Sb	100
W	50

Table 2.--Elements sought but not found in samples of the nonmagnetic fraction of heavy-mineral concentrates from stream sediment from the Ajo quadrangle, Arizona

Element	Limit of detection (parts per million)
As	500
Au	20
Cd	50

Table 3.--Principal characteristics of frequency distributions for elements infrequently detected in samples of minus-30-mesh stream sediment from the Ajo quadrangle

[The minimum was, in all cases, not detectable at the quantity shown in parentheses (parts per million)]

Element	Minimum	Values reported (parts per million)	Frequency of detection
Ag	N(0.5)	1, 1.5	2
Nb	N(20)	20, 30, 70	29
Sn	N(10)	10, 20	2
Zn	N(200)	300	1
Th	N(200)	200, 300, 700	3

Table 4.--Principal characteristics of frequency distributions for elements infrequently detected in samples of the nonmagnetic fraction of heavy-mineral concentrates from stream sediment from the Ajo quadrangle, Arizona

[The minimum was, in all cases, not detectable at the quantity shown in parentheses (parts per million)]

Element	Minimum	Values reported (parts per million)	Frequency of detection
Ag	N(3)	3-500	6
Bi	N(20)	20-2000	34
Sb	N(150)	150-1500	6
W	N(100)	100-10,000	60
Zn	N(1500)	1500-5000	3

Table 5.--Summary statistics for elements detected frequently in samples of minus-30-mesh stream sediment from the Ajo quadrangle.

[Values for Fe, Mg, Ca, and Ti are in percent, all others are in parts per million.]

Element	Minimum[1]	Maximum[1]	Percent valid observations	Geometric mean	Validity of mean[2]	Geometric deviation
Fe	0.5	20	100	6	I	1.6
Mg	0.3	7	100	1.8	I	1.6
Ca	0.3	15	100	2.6	I	1.9
Ti	0.07	G(1.0)	99	0.55	I	1.7
Mn	300	G(5000)	99	1000	I	1.6
Ba	200	5000	100	900	I	1.4
Cr	N(5)	700	93	35	I	2.2
Cu	L(5)	700	89	15	I	2.0
Pb	N(10)	500	99	25	I	1.7
Sr	N(100)	3000	99	700	I	1.6
V	15	700	100	100	I	1.7
Y	N(10)	700	98	25	I	1.8
Zr	30	1000	100	220	I	1.8
Co	N(5)	70	76	5	II	1.7
La	N(20)	500	83	30	II	1.9
Ni	N(5)	200	84	10	II	2.3
Sc	N(5)	30	81	5	II	1.6
B	N(10)	300	39	L(10)	III	--
Be	N(1)	10	49	L(1)	III	--
Mo	N(5)	30	15	L(3)	III	--

[1]Indeterminate letter codes are as follows:
G( ) present in an amount greater than the quantity shown in the parentheses.
L( ) present in an amount less than the quantity shown in the parentheses.
N( ) none detected, the quantity represented by the lowest standard is in parentheses.

[2]The validity of the mean is grouped into three classes as follows:
I. Large proportion of valid observations. Both the mean and geometric deviation are reasonable estimates.
II. Significant proportion of valid observations. The mean may be bracketed with confidence about equal to the analytical precision. The geometric deviation is a minimum estimate.
III. The frequency of valid observations only allows an estimate for the maximum possible value for the mean.

Table 6.--Summary statistics for elements detected frequently in samples of the nonmagnetic fraction of heavy-mineral concentrates from stream sediment from the Ajo quadrangle, Arizona.

[Values for Fe, Mg, Ca, and Ti are in percent, all others are in parts per million]

Element	Minimum[1]	Maximum[1]	Percent valid observations	Mean	Validity of mean[2]	Geometric deviation
Fe	0.3	50	100	6.7	I	2.0
Mg	0.1	20	100	2.4	I	3.4
Ca	1	50	100	1.3	I	2.2
Mn	200	G(10,000)	99	1900	I	2.2
Ba	50	G(10,000)	91	1000	I	3.4
Cr	N(20)	G(10,000)	94	350	I	3.8
La	N(50)	G(5000)	87	1000	I	2.2
Pb	N(20)	15,000	87	50	I	3.0
V	20	1500	100	200	I	1.6
B	N(20)	G(5000)	79	70	II	3.1
Co	N(5)	200	64	5	II	1.7
Cu	N(10)	15,000	78	25	II	3.0
Mo	N(10)	2000	53	7	II	1.9
Nb	N(50)	700	73	30	II	1.8
Ni	N(10)	5000	79	20	II	3.2
Sc	N(10)	G(200)	73	30	II	2.2
Sn	N(20)	G(2000)	76	20	II	2.5
Sr	N(200)	G(10,000)	86	400	II	2.4
Ti	0.1	G(2)	17	>2	III	--
Be	N(2)	20	8	<2	III	--
Y	20	G(1500)	36	>1500	III	--
Zr	50	G(2000)	10	>2000	III	--
Th	N(200)	5000	8	<200	III	--

[1]Indeterminate letter codes are as follows:
G( ) present in an amount greater than the quantity shown in the parentheses.
L( ) present in an amount less than the quantity shown in the parentheses.
N( ) none detected, the quantity represented by the lowest standard is in parentheses.

[2]The validity of the means is grouped into three classes as follows:
I. Large proportion of valid observations. Both the mean and geometric deviation are reasonable estimates.
II. Significant proportion of valid observations. The mean may be bracketed with confidence about equal to the analytical precision. The geometric deviation is a minimum estimate.
III. The frequency of valid observations only allows an estimate for the minimum or maximum possible value for the mean.

Table 7.--Silver and zinc in sediment. Location and analytical data for selected elements in samples of 30-mesh stream sediment from the Ajo quadrangle, Arizona that contain detectable silver or zinc.

Sample number	Latitude			Longitude			Parts per million				
	Deg	Min	Sec	Deg	Min	Sec	Ag	Cu	Mo	Pb	Zn
CP 0675S	32	16	35	113	52	7	1.5	<5	<5	30	N
TM 0780S	32	11	33	113	46	54	N	70	<5	100	300
KP 1100S	32	0	59	112	56	11	1	10	10	50	N

Table 8.--Zinc in concentrates. Location and analytical data for selected elements in samples of the nonmagnetic fraction of heavy-mineral concentrates from stream sediment from the Ajo quadrangle, Arizona that contain detectable zinc.

Sample number	Latitude			Longitude			Parts per million					
	Deg	Min	Sec	Deg	Min	Sec	Zn	Ag	Cu	Mo	Pb	Sb
TM 0778HN	32	13	17	113	48	6	1500	N	<10	<10	20	N
TM 0780HN	32	11	33	113	46	54	5000	N	70	15	500	N
LK 1066HN	31	54	58	112	51	47	3000	N	<10	70	50	N

Table 9.--Silver in concentrates. Location and analytical data for selected elements in samples of the nonmagnetic fraction of heavy-mineral concentrates from stream sediment from the Ajo quadrangle, Arizona that contain 3 parts per million, or more, of silver

Sample number	Latitude			Longitude			Parts per million					
	Deg	Min	Sec	Deg	Min	Sec	Ag	Cu	Mo	Pb	Sb	Zn
KP 1007HN	32	5	56	112	45	6	3	300	30	3000	N	N
AD 1064HN	32	1	5	113	0	38	10	<10	30	150	N	N
LK 1065HN	31	54	20	112	50	59	30	15	200	700	N	N
LK 1067HN	31	54	58	112	51	47	20	300	200	3000	300	N
LK 1068HN	31	49	53	112	51	0	3	70	300	3000	N	N
LK 1070HN	31	57	11	112	50	53	500	70	700	7000	300	N

Table 10.--Antimony in concentrates. Location and analytical data for selected elements in samples of the nonmagnetic fraction of heavy-mineral concentrates from stream sediment from the Ajo quadrangle, Arizona that contain 150 parts per million, or more, of antimony.

Sample number	Latitude			Longitude			Parts per million					
	Deg	Min	Sec	Deg	Min	Sec	Sb	Ag	Cu	Mo	Pb	Zn
HM 0193HN	32	38	58	112	39	20	150	N	50	<10	70	N
HM 0197HN	32	40	33	112	40	26	700	N	150	<10	200	N
KP 0600HN	32	14	24	112	56	46	700	N	150	10	N	N
LK 1067HN	31	54	58	112	51	47	300	20	300	200	3000	N
LK 1070HN	31	57	11	112	50	53	300	500	70	700	7000	N
LK 1089HN	31	59	48	112	50	50	1500	N	<10	30	300	N

Table 11.--Bismuth in concentrates. Location and analytical data for selected elements in samples of the nonmagnetic fraction of heavy-mineral concentrates from stream sediment from the Ajo quadrangle, Arizona that contain detectable bismuth.

Sample number	Latitude			Longitude			Parts per million				
	Deg	Min	Sec	Deg	Min	Sec	Bi	Mo	Pb	Sn	W
AN 0048HN	32	50	23	112	7	32	500	N	1000	N	N
AN 0050HN	32	52	19	112	4	23	300	<10	300	30	N
AN 0051HN	32	52	55	112	4	11	30	<10	700	<20	N
AN 0052HN	32	52	32	112	5	44	30	<10	1000	20	N
AN 0068HN	32	50	30	112	8	42	700	N	1500	50	N
AN 0070HN	32	51	48	112	10	26	100	N	700	N	300
AP 0104HN	32	45	47	112	4	43	20	<10	70	N	N
VM 0105HN	32	43	29	112	7	4	1500	<10	150	N	100
ES 0116HN	32	46	50	112	25	47	50	<10	150	N	N
AZ 0123HN	32	48	3	113	28	53	500	<10	100	30	N
MM 0142HN	32	33	22	113	34	31	<20	15	150	300	700
MM 0143HN	32	33	56	113	35	21	50	10	200	100	700
MO 0149HN	32	45	57	113	45	45	<20	10	70	N	N
MO 0150HN	32	45	59	113	47	14	<20	10	100	20	N
MM 0159HN	32	37	46	113	38	36	70	10	100	100	200
MM 0163HN	32	35	42	113	36	49	100	50	1500	70	3000
ES 0238HN	32	52	4	112	18	52	150	N	300	N	N
ES 0239HN	32	52	38	112	20	54	150	N	300	N	N
ES 0240HN	32	53	8	112	23	2	20	<10	300	20	300
AN 0244HN	32	59	25	112	14	48	50	70	1000	70	2000
ES 0245HN	32	58	53	112	15	24	20	50	300	70	2000
ES 0246HN	32	57	57	112	15	50	<20	10	200	150	N
ES 0248HN	32	57	8	112	18	6	20	<10	1500	N	N
ES 0250HN	32	56	52	112	21	3	<20	10	300	N	N
ES 0251HN	32	56	26	112	19	30	<20	10	150	N	N
ES 0253HN	32	53	46	112	19	1	<20	10	150	<20	N
ES 0257HN	32	54	33	112	27	9	20	15	200	20	150
ES 0258HN	32	55	7	112	25	6	<20	<10	200	<20	100
ES 0271HN	32	56	59	112	26	33	<20	<10	700	100	N
GI 0276HN	32	53	5	112	32	11	2000	<10	300	70	700
ST 0291HN	32	47	39	113	30	14	700	<10	70	20	N
AZ 0321HN	32	59	12	113	19	18	70	N	300	200	N
AJ 0531HN	32	21	40	112	58	15	200	<10	2000	N	N
AJ 0532HN	32	22	23	112	59	3	100	<10	300	70	N
AD 0605HN	32	4	38	113	10	53	700	<10	500	100	200
AD 0606HN	32	3	56	113	11	33	300	<10	100	30	3000
OH 0611HN	32	4	26	113	15	45	70	<10	500	70	100
AD 0614HN	32	4	53	113	13	23	1000	<10	300	70	100
AD 0615HN	32	5	2	113	12	41	<20	<10	150	70	500
AD 0616HN	32	4	58	113	11	24	150	10	70	<20	N
AD 0695HN	32	7	5	113	10	38	50	<10	150	200	N
OH 0706HN	32	4	53	113	21	42	100	10	3000	50	N
IP 0730HN	32	17	54	113	34	32	70	10	70	N	N
KP 1037HN	32	7	52	112	57	36	70	20	70	50	N
KP 1050HN	32	6	43	112	59	14	<20	15	150	30	N

Table 12.--Tungsten in concentrates. Location and analytical data for selected elements in samples of the nonmagnetic fraction of heavy-mineral concentrates from stream sediments from the Ajo quadrangle, Arizona that contain detectable tungsten.

Sample number	Latitude			Longitude			Parts per million				
	Deg	Min	Sec	Deg	Min	Sec	W	Bi	Mo	Pb	Sn
IP 0044HN	32	28	48	113	32	14	500	N	15	70	20
AN 0061HN	32	51	55	112	9	10	<100	N	N	1500	50
AN 0070HN	32	51	48	112	10	26	100	100	N	700	N
AP 0099HN	32	46	17	112	10	42	3000	N	30	30	N
VM 0105HN	32	43	29	112	7	4	100	1500	<10	150	N
VM 0106HN	32	43	39	112	9	50	1500	N	15	70	N
ES 0117HN	32	46	58	112	24	39	150	N	<10	70	N
ES 0118HN	32	46	51	112	22	52	700	N	20	100	N
MM 0141HN	32	33	7	113	37	6	300	N	<10	100	20
MM 0142HN	32	33	22	113	34	31	700	<20	15	150	300
MM 0143HN	32	33	56	113	35	21	700	50	10	200	100
MM 0144HN	32	34	0	113	36	1	700	N	50	3000	70
MM 0145HN	32	34	39	113	36	14	500	N	20	150	N
MM 0146HN	32	35	3	113	37	15	2000	N	700	2000	20
RO 0148HN	32	45	15	113	45	6	300	N	20	200	50
MO 0151HN	32	45	7	113	46	40	300	N	30	50	50
MM 0159HN	32	37	46	113	38	36	200	70	10	100	100
MM 0162HN	32	36	20	113	36	56	1500	N	20	500	50
MM 0163HN	32	35	42	113	36	49	3000	100	50	1500	70
MM 0174HN	32	44	49	112	47	46	200	N	<10	100	50
ES 0240HN	32	53	8	112	23	2	300	20	10	300	20
ES 0241HN	32	53	12	112	24	41	300	N	15	30	N
ES 0244HN	32	59	25	112	14	48	2000	50	70	1000	70
ES 0245HN	32	58	53	112	15	24	2000	20	50	300	70
ES 0247HN	32	57	21	112	15	9	150	N	10	70	N
ES 0257HN	32	54	33	112	27	9	150	20	15	200	20
ES 0258HN	32	55	7	112	25	6	100	<20	<10	200	<20
GI 0265HN	32	59	41	112	30	16	3000	N	20	300	50
ES 0269HN	32	58	5	112	29	12	300	N	<10	700	<20
ES 0272HN	32	56	23	112	25	15	150	N	15	500	30
GI 0276HN	32	53	5	112	32	11	700	2000	<10	300	70
MO 0299HN	32	53	2	113	56	53	150	N	N	1000	50
RO 0305HN	32	55	5	113	59	32	3000	N	<10	150	N
RO 0307HN	32	53	58	113	59	34	2000	N	70	150	50
HM 0373HN	32	44	29	112	32	22	300	N	15	70	<20
GP 0502HN	32	16	34	113	14	55	700	N	20	150	70
GM 0506HN	32	19	7	113	16	29	300	N	<10	100	70
AJ 0533HN	32	20	32	112	56	48	<100	N	15	200	20
AJ 0534HN	32	20	13	112	56	11	700	N	200	500	30
AD 0574HN	32	2	42	113	9	30	1500	N	150	700	20
AD 0575HN	32	2	19	113	8	42	1500	N	70	100	30
AD 0580HN	32	0	43	113	10	32	300	N	30	150	20
KP 0595HN	32	12	12	112	53	53	10000	N	2000	1500	700
KP 0596HN	32	12	38	112	54	54	200	N	70	30	N
KP 0597HN	32	13	8	112	55	44	700	N	30	N	50
AD 0605HN	32	4	38	113	10	53	200	700	<10	500	100
AD 0606HN	32	3	56	113	11	33	3000	300	<10	100	30
OH 0611HN	32	4	26	113	15	45	100	70	<10	500	70
OH 0612HN	32	5	10	113	15	39	300	N	15	150	70
AD 0614HN	32	4	53	113	13	23	100	1000	<10	300	70
AD 0615HN	32	5	2	113	12	41	500	<20	<10	150	70
CP 0687HN	32	21	45	113	49	3	300	N	20	200	100
CP 0765HN	32	19	24	113	47	32	300	N	<10	500	30
SA 0807HN	32	14	16	113	42	28	700	N	50	500	30
QB 1055HN	31	59	12	113	2	53	150	N	10	700	70
QB 1057HN	31	59	45	113	1	48	500	N	20	500	<20
AD 1064HN	32	1	5	113	0	38	<100	N	30	150	20
LK 1065HN	31	54	20	112	50	59	1500	N	200	700	70
LK 1066HN	31	54	58	112	51	47	300	N	70	50	30
LK 1067HN	31	55	29	112	50	1	300	N	200	3000	20
LK 1068HN	31	55	53	112	51	0	200	N	300	3000	N
LK 1069HN	31	56	29	112	51	25	150	N	200	1000	N
LK 1070HN	31	57	11	112	50	53	100	N	700	7000	150
LK 1073HN	31	58	46	112	53	40	<100	N	20	200	N

Table 13.--Niobium in sediment. Location and analytical data for selected elements in samples of 30-mesh stream sediment from the Ajo quadrangle, Arizona that contain 20 parts per million, or more, of niobium.

Sample number	Latitude Deg	Min	Sec	Longitude Deg	Min	Sec	Parts per million Nb	Be	La	Sn	Y	Zr	Ti
AN 0050S	32	52	19	112	4	23	30	2	100	N	100	500	1
AN 0052S	32	52	32	112	5	44	20	5	150	N	70	300	.7
AN 0060S	32	51	14	112	8	54	30	7	70	N	70	150	1
AN 0068S	32	50	30	112	8	42	20	5	150	N	150	300	.3
AN 0070S	32	51	48	112	10	26	20	2	100	N	150	700	<1
MO 0149S	32	45	57	113	45	45	70	N	150	N	20	700	.5
MO 0150S	32	45	59	113	47	14	20	N	N	N	20	300	.5
HM 0188S	32	42	22	112	42	10	30	2	50	N	30	500	1
HM 0194S	32	40	11	112	39	19	20	1	200	20	100	700	>1
OH 0495S	32	12	57	113	17	5	30	1	50	N	70	300	>1
AJ 0556S	32	18	37	112	58	2	20	1	150	N	70	700	>1
AJ 0557S	32	17	41	112	57	49	20	1	70	N	50	700	1
AJ 0560S	32	17	53	112	56	15	20	2	70	N	70	700	1
AD 0583S	32	2	32	113	12	16	20	1	N	N	70	700	>1
KP 0593S	32	12	17	112	58	32	20	5	50	N	30	150	.3
SI 0603S	32	29	2	112	40	56	30	3	50	N	30	150	.3
AD 0607S	32	3	27	113	12	53	20	1	150	N	150	500	1
CP 0677S	32	15	14	113	51	23	30	2	150	N	70	200	.7
AD 0695S	32	7	5	113	10	38	30	2	100	N	70	700	1
OH 0698S	32	6	15	113	15	22	20	1	200	N	300	500	1
OH 0719S	32	11	39	113	26	34	30	3	100	N	70	300	.7
OH 0725S	32	10	1	113	25	34	20	3	150	N	70	500	1
OH 0726S	32	9	46	113	26	41	20	2	200	N	100	700	1
OH 0729S	32	12	37	113	29	44	20	1	70	N	100	700	1
KP 1041S	32	10	52	112	57	46	20	N	50	N	20	100	.15
LK 1075S	31	59	57	112	51	50	20	N	50	N	30	100	.1
KP 1086S	32	1	45	112	52	35	20	N	70	N	30	100	.15
LK 1089S	31	59	48	112	50	50	20	N	50	N	30	100	.15
MA 1115S	32	2	59	112	38	56	30	N	50	N	30	200	1

Table 14.--Tin in sediment. Location and analytical data for selected elements in samples of 30-mesh stream sediment from the Ajo quadrangle, Arizona that contain 10 parts per million, or more, of tin.

Sample number	Latitude			Longitude			Parts per million					
	Deg	Min	Sec	Deg	Min	Sec	Sn	Be	La	Nb	Y	Zr
MI 0186S	32	41	23	112	48	9	10	2	70	N	20	150
HM 0194S	32	40	11	112	39	19	20	1	200	20	100	700

Table 15.--Thorium in sediment. Location and analytical data for selected elements in samples of 30-mesh stream sediment from the Ajo quadrangle, Arizona that contain 200 parts per million, or more, of thorium.

Sample number	Latitude			Longitude			Parts per million				
	Deg	Min	Sec	Deg	Min	Sec	Th	V	La	Pb	Mo
MM 0172S	32	41	35	113	44	50	300	300	N	10	<5
CP 0672S	32	19	31	113	52	55	700	150	50	20	<5
OH 0689S	32	12	25	113	16	29	200	100	200	30	<5