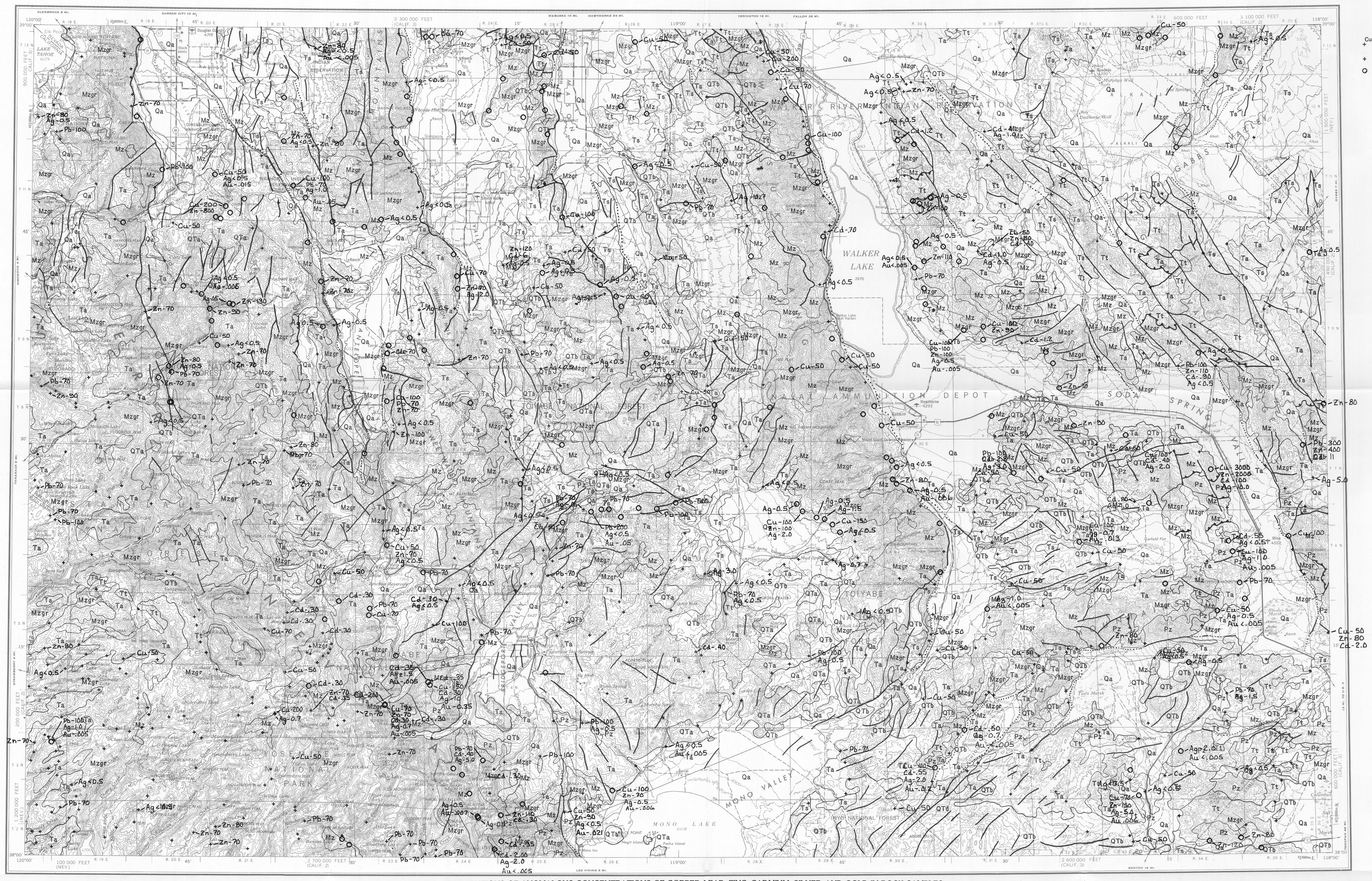


MAP A. DISTRIBUTIONS OF ANOMALOUS CONCENTRATIONS OF COPPER, LEAD, ZINC, CADMIUM, SILVER, AND GOLD IN ROCK SAMPLES

EXPLANATION

Cu-60 SAMPLE LOCALITY--Showing anomalous concentration of one or more elements

+ SAMPLE LOCALITY--Fresh rock sample

O SAMPLE LOCALITY--Altered rock sample

Table 1.--Summary of background and anomalous ranges for 12 selected elements in 815 samples of rock, Walker Lake quadrangle, California and Nevada

[All analyses are spectrographic except as noted. AA = atomic-absorption analysis. CM = colorimetric analysis. All concentrations in parts per million. N = not detected at the lower limit of determination shown in parentheses]

	Background samples		Anomalous samples	
Element	Range of values	Percent of total samples	Range of values	Percent of total samples
Cu	N(5) - 30	91	50-300	9
Pb	N(10) - 50	95	70-500	5
Zn-AA	N(5) - 65	92	70-2,000	8
Cd-AA	N(0.05) - 0.25	96	0.30- 100	4
Ag	N(0.5)	87	<0.5- 10	13
Au-AA	N(0.005)	1/	<0.005- 0.35	1/
Mo	N(5) - 5	92	7->2,000	8
W	N(50)	96	<50 - 500	4
Sn	N(10)	99	10 - 50	1
As-CM	N(10) - <10	92	10 - 160	8
Sb-AA	N(1) - 2	91	3 - 200	9
Bi-AA	N(0.5) - 2.0	98	2.5- 280	2

1/ No percentages are given because only 97 out of 815 samples were analyzed for gold.

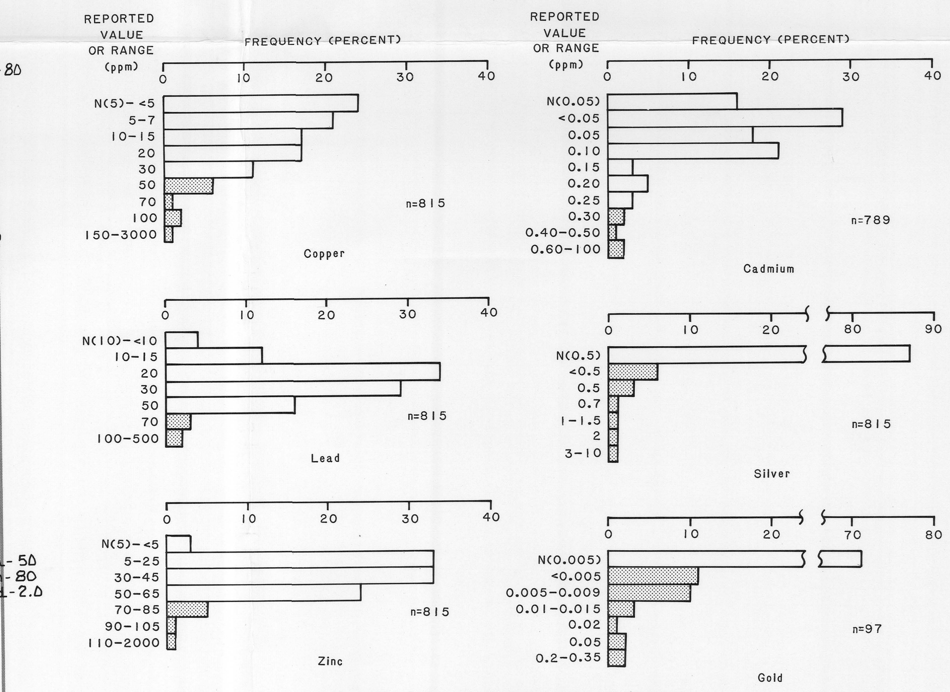
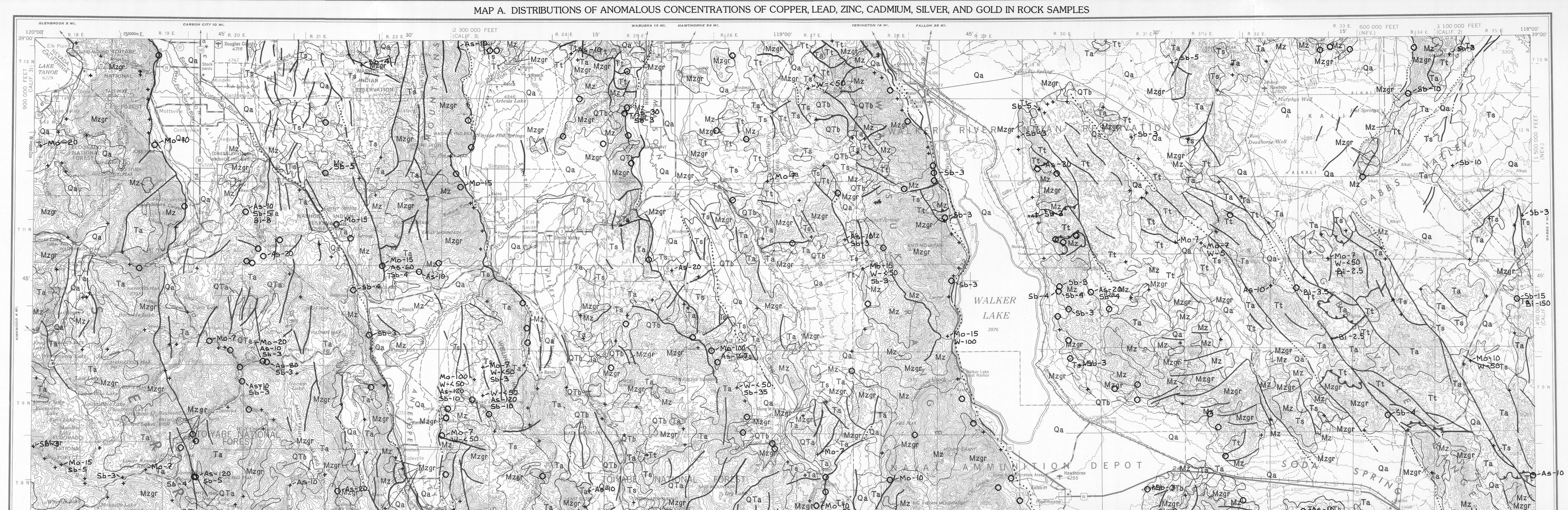


Figure 1.--Frequency-distribution histograms for copper, lead, zinc, cadmium, silver, and gold in rock samples. N, not detected at lower limit of determination shown in parentheses. n, number of samples in data set. Shaded bars indicate those concentrations considered to be anomalous.



MAP B. DISTRIBUTIONS OF ANOMALOUS CONCENTRATIONS OF MOLYBDENUM, TIN, TUNGSTEN, ARSENIC, ANTIMONY, AND BISMUTH IN ROCK SAMPLES

Base from U.S. Geological Survey, 1957; revised 1969

Geology simplified from Stewart and others, 1982

SCALE 1:250 000

CONTOUR INTERVAL 200 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929

EXPLANATION

Mo-7 SAMPLE LOCALITY--Showing anomalous concentration of one or more elements

+ SAMPLE LOCALITY--Fresh rock sample

O SAMPLE LOCALITY--Altered rock sample

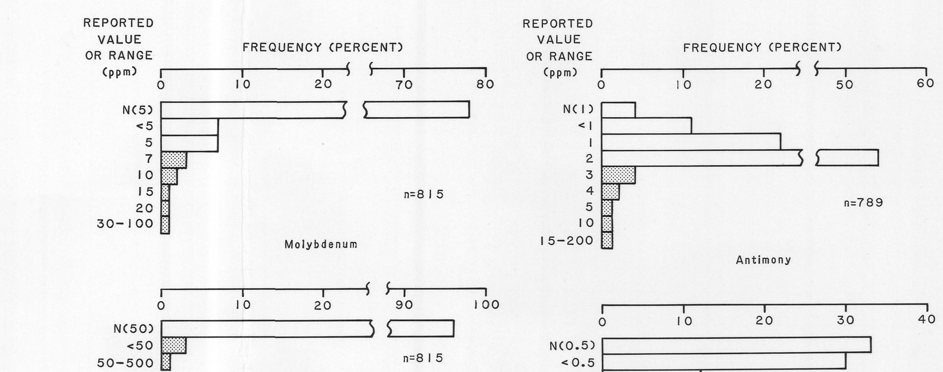
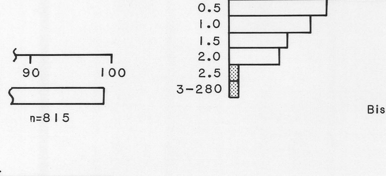


Figure 2.--Frequency-distribution histograms for molybdenum, tungsten, tin, arsenic, antimony, and bismuth in rock samples. N, not detected at lower limit of determination shown in parentheses. n, number of samples in data set. Shaded bars indicate those concentrations considered to be anomalous.

Note: The following correlation and description of map units are for the geologic base map shown in gray

CORRELATION OF MAP UNITS



DESCRIPTION OF MAP UNITS

Qa ALLUVIAL, LACUSTRINE, EOLIAN, LANDSLIDE, AND GLACIAL DEPOSITS, UNDIVIDED (QUATERNARY)--As mapped locally includes uppermost Tertiary gravel

QTb BASALT (QUATERNARY AND TERTIARY)--Ranges in age from about 9 m.y. to less than 1 m.y.

QTa ANDESITE TO RHYOLITE (QUATERNARY AND TERTIARY)--Andesite flows and breccia. Minor rhyolitic flows and shallow intrusive rocks. Ranges in age from about 5 m.y. to less than 1 m.y.

Ts SEDIMENTARY ROCKS (TERTIARY)--Tuffaceous sandstone, siltstone, and conglomerate to gravel. Minor tuff and volcanic breccia. Ranges in age from about 12 m.y. to 2 m.y.

Ta ANDESITE TO RHYOLITE (TERTIARY)--Andesite flows and breccia. Minor rhyolitic flows and shallow intrusive rocks, latitic to rhyolitic ash-flow tuffs, and sedimentary rocks; sparse basalt; includes some intrusive rocks. Ranges in age from about 22 m.y. to 5 m.y.

Tt TUFF (TERTIARY)--Welded and nonwelded rhyolitic ash-flow tuff. Minor rhyolite flows and shallow intrusive rocks, andesite flows, and sedimentary rocks; sparse basalt; includes some intrusive rocks. Ranges in age from 30 m.y. to 22 m.y.

Mzgr GRANITIC ROCKS (MESOZOIC)--Granite to granodiorite. Minor dioritic, gabbroic, and felsic intrusive rocks

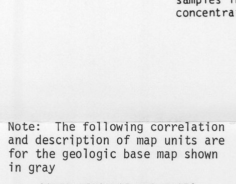
Mz VOLCANIC AND SEDIMENTARY ROCKS, UNDIVIDED (MESOZOIC)--Andesitic to rhyolitic lava flows, breccia, tuff, volcanic sandstone, and conglomerate; shallow marine siltstone, sandstone, conglomerate, and limestone; continental sandstone and conglomerate. Metamorphosed near granitic rocks

Pz SEDIMENTARY AND VOLCANIC ROCKS, UNDIVIDED (PALEOZOIC)--Deep-water marine chert, phyllite, shale, carbonate rocks, volcanogenic turbidite, sandstone, and conglomerate (Ordovician, Devonian, Pennsylvanian, and Permian); shallow-water siltstone, sandstone, conglomerate, and carbonate (Cambrian, Mississippian, and Permian; as mapped includes upper Proterozoic rocks at one locality); and andesitic breccia and lava (Permian). Metamorphosed near granitic rocks

GEOLOGIC CONTACT

HIGH-ANGLE FAULT--Dotted where concealed

THRUST OR LOW-ANGLE FAULT



QUADRANGLE LOCATION

INTRODUCTION

This report is part of a folio of maps of the Walker Lake 1° x 2° quadrangle, California and Nevada, prepared under the Conterminous United States Mineral Assessment Program. The folio includes geological, geochemical, and geophysical maps, as well as mineral resource assessment maps, which identify selected known or possible mineral-deposit environments in the quadrangle. The geochemical maps show the distributions of selected individual elements (Chaffee and others, 1988a, b, c) and the distributions of selected groups of elements (Chaffee, 1988a, b, c). Discussions accompanying the individual element maps are restricted to possible mineral residences of the individual elements as well as to what types of mineral deposits and environments may be represented by anomalies of a particular element. Discussions accompanying the multielement maps describe the possible types of mineral deposits that may be related to each element group and indicate the most favorable localities for these deposits.

This chapter of the folio shows the abundances and distributions of anomalous concentrations of selected mineral-deposit-related elements in 815 samples of rock. Analyses for 26 rock samples included in this report are from samples collected and analyzed during 1967 and 1968 for the Emigrant Basin Primitive Area study (Tooker and others, 1970). The rest of the samples were collected and analyzed during 1978 and 1979, specifically for the present report. A combined tabulation of all these analyses is published as U.S. Geological Survey Open-File Report 80-881 (Chaffee and others, 1980). This same tabulation is also available on computer tape from the National Technical Information Service (McDanal and others, 1981).

GENERAL GEOLOGY

The Walker Lake quadrangle includes parts of two major physiographic provinces: the Sierra Nevada-Cascade Mountains and the Basin and Range provinces. These two provinces have contrasting geological frameworks that reflect their different geologic histories. Because the geology of the Walker Lake quadrangle is complex, only a brief generalized summary is given here.

Sierra Nevada-Cascade Mountains province

Most of the western one-third of the quadrangle is in the Sierra Nevada. The Sierra Nevada includes the major Sierra Nevada batholith, which is composed of plutons ranging from Permian(?) to Late Cretaceous in age (Keith and Seitz, 1981). These plutons range from alaskite to gabbro in composition, with the majority of the rocks being in the quartz monzonite to granodiorite range. This plutonic complex has intruded and metamorphosed a sequence of Paleozoic and Mesozoic rocks that comprise both clastic- and carbonate-rich sedimentary rocks as well as volcanic (and plutonic?) rocks. Overlying these older units locally are Tertiary volcanic rocks consisting of flows, breccias, and lahars, and intrusive dikes, sills, and necks. Most of these Tertiary volcanic rocks are andesitic in composition; however, rocks of rhyolitic composition are present locally. Glacial and landslide deposits are present in many of the valleys in the Sierra Nevada.

Basin and Range province

Most of the eastern two-thirds of the quadrangle is in the Basin and Range physiographic province. Much of this part of the quadrangle contains thick sequences of extensively block-faulted Paleozoic and Mesozoic sedimentary rocks of widely varying compositions. Mesozoic plutons, which range in composition from alaskite to gabbro but are predominantly in the granite to granodiorite range, have intruded and locally metamorphosed the overlying sedimentary rocks. A long history of Tertiary volcanism is recorded in the eastern part of the quadrangle; thick sequences of flows, breccias, and tuffs, ranging in composition from rhyolite to basalt, are found throughout much of the area. Tertiary clastic sedimentary rocks were deposited in some areas. Tertiary and Quaternary volcanic flows, breccias, and shallow intrusive rocks, ranging in composition from rhyolite to basalt, are also present locally. Alluvial, lacustrine, and eolian sedimentary deposits are present in most of the valleys in this part of the quadrangle.

Geologic base for the geochemical maps

A simplified geologic base map of the Walker Lake quadrangle has been used with each of the accompanying geochemical maps. A more detailed geologic map of the quadrangle is available as a separate chapter in this Walker Lake folio (Stewart and others, 1982). For purposes of discussion in this report, some of the geologic units shown on the geologic map of Stewart and others (1982) have been consolidated into three major units.

Paleozoic and Mesozoic rocks--All of the pre-Cretaceous (Paleozoic and Mesozoic) igneous and sedimentary rock units (units Pz and Mz on map) have been consolidated into this one unit. Many but not all of these rocks have been metamorphosed.

Mesozoic intrusive rocks--Plutons ranging in composition from alaskite to gabbro compose this unit (unit Mzgr on map).

Tertiary volcanic rocks--This unit is composed predominantly of flow rocks of andesitic composition, but it also includes necks and flows ranging in composition from rhyolite to basalt as well as felsic to intermediate tuffs (includes units Tt and Ta on map).

ECONOMIC GEOLOGY

The Walker Lake quadrangle contains many mines and prospects. As a result of the complex geologic history of the area, many different mineral-deposit environments exist within the quadrangle. On the basis of geological and geochemical studies conducted for the reports in this folio, as well as on the recorded mining in the region, the commodities thought to have the greatest resource potential within the Walker Lake quadrangle are copper, lead, zinc, gold, silver, molybdenum, tungsten, and uranium. Thus, this geochemical study emphasizes those elements and element suites that may prove useful in locating areas containing (1) base and precious metals[1] and tungsten in vein or contact-metasomatic deposits, (2) copper and (or) molybdenum porphyry-type deposits, and (3) disseminated gold deposits. Studies related to uranium deposits are described elsewhere (Durham and Felmlee, 1982; Fay and Jones, 1980).

[1] The term base metals in this report includes some or all of the elements antimony, arsenic, bismuth, cadmium, copper, lead, and zinc. The precious metals are silver and gold.

NATURE AND SCOPE OF THE GEOCHEMICAL SAMPLING

The geochemical sampling program for the Walker Lake quadrangle was based on collecting as many as three different types of samples--rock, minus-60-mesh stream sediment, and nonmagnetic heavy-mineral concentrate derived from stream sediment--at preselected locations throughout the quadrangle. Additional rock samples were collected at locations selected in the field during the geologic mapping. This chapter of the folio discusses only the results from rock samples; the results from stream-sediment and concentrate samples are discussed in other chapters of this folio (Chaffee, 1988a, b, c; Chaffee and others, 1988a, b, c).

The chemical analyses of the rock samples provide information that may be used to separate the background concentrations of the elements studied from their anomalous concentrations. This information is useful in defining anomalous ranges for these elements both in rock samples and, to some extent, in stream-sediment samples. Anomalous concentrations may indicate the presence of as yet unknown mineral deposits that may be either exposed or buried. Plots of the analyses can be used to identify the areas or favorable host rock units that may contain mineral deposits.

Because the sampling was designed and executed on a reconnaissance scale, many exposures that may contain anomalous elements may not have been identified. Mineral deposits not exposed at the surface may not be easily detected even if part of the deposit system, such as an alteration aureole, is exposed. Additional detailed geochemical surveys would be necessary to identify and delineate specific mineralized areas.

SAMPLE COLLECTION, PREPARATION, AND ANALYSIS

Most of the rock samples were collected from outcrops considered to be representative of the general area around the plotted locality. Where two distinctly different rock types were present in roughly equal proportions at the selected site, the unit considered more likely to be a potential host rock for mineralization was collected. The majority of the rock samples were collected to provide information on chemical abundances of selected elements in typical rock material at a given location. Additionally, some samples were deliberately collected from obviously mineralized outcrops to test for ore-related elements in minerals that might not be identified by a visual examination.

All samples were hand-cobbed whenever possible to remove obviously weathered surface material and then crushed and pulverized. The rock samples were analyzed for 31 elements (Ag, As, Au, B, Ba, Be, Bi, Ca, Cd, Co, Cr, Cu, Fe, La, Mg, Mn, Mo, Nb, Ni, Pb, Sb, Sc, Sn, Sr, Th, Ti, V, W, Y, Zn, and Zr) using a six-step semiquantitative emission spectrographic method (Grimes and Marranzino, 1968). They were also analyzed for arsenic by colorimetry (Ward and others, 1963), for zinc, antimony, and gold (only 97 samples) by atomic-absorption spectrometry (Ward and others, 1969; Welsch and Chao, 1975; Meier, 1980), and for cadmium and bismuth from a single solution by atomic-absorption spectrometry (Viets, 1978). Analyses for both sample types were performed partly in the field in a mobile chemistry laboratory and partly in U.S. Geological Survey laboratories near Golden, Colo.

The spectrographic analytical values are reported as the approximate geometric midpoints (0.15, 0.2, 0.3, 0.5, 0.7, and 1.0, or appropriate powers of ten of these values) of concentration ranges whose respective boundaries are 0.12, 0.18, 0.26, 0.38, 0.56, 0.83, and 1.2 (or appropriate powers of ten of these values). In general, the precision of the spectrographic method is plus or minus one reporting value of the value given by the analyst approximately 83 percent of the time and plus or minus two reporting values of the value given by the analyst 96 percent of the time (Motooka and Grimes, 1976). A reference standard sample was analyzed with each batch of field samples to monitor the quality of the analyses.

For the six elements analyzed by colorimetry or atomic-absorption spectrometry, the reporting values vary with the element and with the concentration level for any given element. Precision for these analytical methods is commonly reported as a percent relative standard deviation and is based on replicate analyses of samples selected to provide information at different concentration levels. In general, the precision for each method tends to be lowest for those samples containing a given element at or near its lower limit of determination. For the six elements discussed in the geochemical chapters in this folio, the reported ranges of percent relative standard deviation (RSD) are as follows:

Element	Range of percent RSD	Source of data
As	0.0-48.9	Unpublished analyses by R. H. Hill, 1981
Zn	3.4-30.2	Ward and others, 1969, p. 21
Sb	3.7-10.7	Welsch and Chao, 1975
Au	0.0-22.8	Meier, 1980
Cd	3.3-18.8	Viets, 1978
Bi	1.4-4.0	Viets, 1978

As an example to use in interpreting these ranges, one might consider antimony, whose range is shown as 3.7-10.7 percent RSD. This range indicates that a reported antimony value should be within ± 10.7 percent (usually much less) of the mean value for that sample.

EVALUATION OF THE CHEMICAL ANALYSES

Of the 37 elements determined in the rock samples, 12 elements (Ag, Cu, Mo, Pb, Sn, and W, by emission spectroscopy; Au, Bi, Cd, Sb, and Zn, by atomic-absorption spectrometry; and As, by colorimetry) were selected as possibly being associated with hydrothermal alteration and (or) mineralization of the types known or thought to exist in the Walker Lake quadrangle.

On the basis of a study of the frequency-distribution histogram for each element population (figs. 1-2) and the areal distribution of the analytical values for each element, we have selected what we feel is the best threshold value for that element. Table 1 summarizes background and anomaly ranges for the 12 elements.

DISCUSSION OF THE MAPS

Maps A and B show the distributions of anomalous concentrations of 12 elements (Ag, Au, Cd, Cu, Pb, and Zn on map A; As, Bi, Mo, Sb, Sn, and W on map B) in 815 rock samples. A large number of chemically very different rock types were sampled. As a result, many of the anomalies shown on these two maps may not be related to mineral deposits; they may instead only be high but normal concentrations for a particular rock type. Of the anomalies shown on the maps, the most significant from a mineral potential standpoint are those (1) associated with hydrothermal alteration, (2) containing more than one anomalous element, and (or) (3) containing concentrations for each anomalous element at the high end of its range as shown in table 1.

Each rock sample represents material collected from an essentially single point source whereas the stream-sediment and heavy-mineral concentrate samples discussed in other chapters of this folio may represent material eroded from the same outcrop as the rock sample but, more likely, represent material eroded from a large number of outcrops upstream from the outcrop actually sampled. Because of these facts, the analyses of the rock samples should be considered to represent a third source of geochemical information that may not be related in any way to the analyses of the stream-sediment and concentrate samples. It is recommended that all of the maps in this folio be consulted as part of any decision-making process.

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MAPS SHOWING DISTRIBUTION OF 12 SELECTED ELEMENTS IN SAMPLES OF ROCK, WALKER LAKE 1° X 2° QUADRANGLE, CALIFORNIA AND NEVADA

By

M.A. Chaffee, R.H. Hill, and S.J. Sutley

1988

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