U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

MISCELLANEOUS FIELD STUDIES MAP MF-2407-G version 1.0

Map Showing Arsenic Concentrations from Stream Sediments and Soils Throughout the Humboldt River Basin and Surrounding Areas, Northern Nevada

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NATIONAL VERTICAL GEODETIC DATUM OF 1929

CONTOUR INTERVAL 500 FEET

SCALE 1:500,000

Base from U.S. Geological Survey, 1965
Lambert Conformal Conic Projection
based on standard parallels 33 degrees and 45 degrees

The distribution of arsenic in stream sediments and soils in the Humboldt River basin and surrounding area

In 1995, the U.S. Bureau of Land Management and the U.S. Geological Survey identified arsenic along with 12 other elements to investigate within the Humboldt River basin located in northern Nevada. These elements are important because of their role as pathfinder elements for mineral deposits or as potential toxins in the environment. This report is one of 13 separate published reports (MF-2407-A-M) that integrate the results of two geochemical studies conducted by the U.S. Geological Survey and that present geochemical maps created using computer models of stream-sediment and soil geochemistry. The other 12 reports present geochemical maps for Ag, Au, Ce, Co, Cu, Fe, Ni, Pb, Sb, Sc, Se, and Zn. These geochemical maps provide a visual aid to interpreting the trends and anomalies in element concentration when combined with information about the geology, topography, and mining districts in the Humboldt River basin.

The Humboldt River basin is a naturally occurring, internally draining river basin that covers approximately 43,700 square kilometers (16,900 square miles) and forms a substantial part of the larger Great Basin. The Humboldt River basin includes the upper reaches of the Little Humboldt River in Elko County, the Reese River in Lander County, and the main Humboldt River and its many tributaries that flow ultimately westward into the Humboldt Sink. Figure 1 shows the map area and the Humboldt River basin. Stream-sediment and soil samples originally collected for the NURE (National Uranium Resource Evaluation) program were reanalyzed in 1994 for the Winnemucca-Surprise mineral resource assessment (3,524 samples; King and others, 1996) and in 1996 for the mineral and environmental assessment of the Humboldt River basin (3,626 samples; Folger, 2000) (figure 2). An additional 206 stream-sediment samples were collected for the Winnemucca-Surprise mineral resource assessment by the USGS to fill gaps in the sample coverage. The combined sample coverage is generally spatially uniform with a sample density of one sample site per 17 square kilometers. Sample density is greatest along range fronts and sparsest along mountain ridges and broad valley bottoms.

Sample analysis

The -80 (<180 ∝m) and -100 (<150 ∝m) sieve mesh grain-size fractions of stream-sediment and soil samples were selected for reanalysis. The samples were prepared and analyzed using a weak acid digestion and organic extraction prior to analysis by inductively coupled plasma-atomic adsorption spectrometry (ICP-AES) (Motooka, 1996). This digestion method cannot dissolve complex silicates and therefore may underestimate the total arsenic present in the sample. However, the method does permit measurement at low detection levels. There were 384 qualified values (below the limit of detection) in the Winnemucca-Surprise and none in the Humboldt River basin datasets. Prior to computing the statistics and subsequent grids, all qualified values were replaced with a value equal to 2/3 of the lower detection level. Table 1 contains the statistical profiles and lower limits of determination (LLD) of the two data sets. Figure 3 shows the lognormal distribution of the data. The histograms illustrate the overwhelming effect of qualified values (tallest yellow bar on left) on the distribution statistics in the Winnemucca-Surprise study. To enhance the continuity of data, the two data sets were combined into a single data set and plotted on the thematic map.

Arsenic (As), a trace element and a metalloid, is highly chalcophilic with an affinity to form sulfide minerals and complex with metals. The chalcophile characteristics of arsenic make it a useful "pathfinder" element in the exploration for mineral deposits. Arsenic is also a potential stressor or toxin to biologic systems (Eisler, 1988; WHO, 1981). Arsenic is distributed relatively uniformly among rock types globally, with the average concentration ranging from 0.5 to 2.5 ppm, with the exception of argillaceous sediments, which average 13 ppm (Kabata-Pendias and Pendias, 1992). Arsenic concentrations in the Humboldt River basin range from below detection levels (0.6 ppm) to 1785 ppm. The environmental consequences of arsenic enriched in stream sediments and soils are dependent on the solubility of the arsenic minerals or compounds present in them. The mobility of soluble arsenic in soils and surface water is limited by its strong sorption to clays, hydroxides, and organic matter. However, under reducing conditions, arsenic sorption is limited and its mobility enhanced (Welch and others, 2000).

Construction of thematic maps

The thematic map is a useful format for representing the regional variation in geochemical concentration between samples. The approach used for each dataset was to (a) transform every concentration to the logarithm of the concentration for the element and (b) calculate the mean and standard deviation of the log-transformed data. Element concentrations are now expressed as a logarithm and are classified by standard deviations above or below the mean. The standard deviation category for each sample is indicated by a color symbol. Samples with standard deviations below the mean were assigned the "cool" hues of blues and greens, and samples with standard deviations above the mean were assigned the "warm" hues of gold, orange, and red.

A small geochemistry map (fig. 4) was generated from the data using a Geosoft software version of the minimumcurvature algorithm. The minimum-curvature algorithm (Briggs, 1974; Webring, 1981) is useful in fitting a surface to closely spaced and gradually varying data while interpolating smoothly between widely spaced data. Data gaps, while conservatively interpolated, may occasionally allow the surface to overshoot or undershoot. Contour intervals on the thematic map are calculated from the minimum curvature grid values and provide an indicator of the generalized spatial continuity of geochemical trends. Contour lines (in brown) left unclosed reflect the sparseness of data available in these areas.

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Figures
Figure 2. Winnemucca-Surprise mineral resource assessment and Humboldt River basin mineral and environmental assessment sample localities in green and red, respectively.
Figure 3. Overlapping histograms of log-transformed arsenic values. Humboldt River basin in blue and Winnemucca-Surprise in yellow, and where there is overlap, the histograms are green.
Figure 4. Continuous surface model of As analyses.

Table 1. Statistics for arsenic. LLD, lower limit of determination; N, number; Dev, deviation.

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digital files, on an electronic plotter. It is also
available as a PDF file at http://geology.cr.usgs.gov