Identifying potential contaminant sources using sediment geochemical data sets

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Abstract

Geochemical data sets provide an easy access to spatially distributed concentrations of contaminants. These data are most useful in environmental studies of large areas (i.e. > 25 x 25 km) where the number of data points within the area of interest is large enough to form a visible pattern and statistical manipulations are more meaningful. This study was based on sediment concentrations of As, Cu, and Pb in a 2° x 2° area within the state of Chihuahua, Mexico. The results show anomalous concentrations in association with mining and mineral deposits for all three metals, and a concentration pattern for non-anomalous concentrations that is unique for each metal. The format in which these data are stored allows for adding new data, which makes this a versatile tool for environmental studies.

Introduction

Geochemical data bases have increased in number over the past few decades covering an increasingly large portion of the land area. These data bases usually report metal (and other elements) contained in sediment, whose content is determined after a standard procedure of digestion with *aqua regia* followed by elemental determination by spectrometry using an ICP-MS. Although these geochemical data bases were originally intended for geochemical exploration purposes, they provide an inexpensive and accessible information source for environmental studies. Furthermore, sediment composition has been widely utilized for environmental assessment purposes (Förster *et al.*, 1990) as, in contrast to water, sediments integrate contaminant concentrations over time.

Examples of geochemical data bases include the Global Reference Network that intends to compile geochemical data from all around the globe, the Geochemical Atlas of Europe, the National Uranium Resource Evaluation Data in the U.S., and the tri-national USGS Geochemical Landscapes Project for North America. As part of the latter, sediment geochemical data for Chihuahua, Mexico, were compiled in 2001 by the Servicio Geologico Mexicano (SGM, 2001).

The area selected for this study comprised a region of northeast Chihuahua (28-30°N, 104-106°W). This area includes segments of the Rio Conchos, Rio Grande, the city of Delicias, the irrigation district 005 near Delicias, and several active and abandoned mines (oxides, sulfides, and barite) among which La Perla (Fe) and San Antonio (Pb, Zn) are active. Previous studies using geochemical sediment data for this area have been reported (Gutierrez et al., 2007; Gutierrez et. al., in press).

Materials and Methods

The data were comprised on two CD-roms available from the Servicio Geologico Mexicano under the *Paquete Digital Interactivo* trade name. According to SGM protocols (SGM, 2001) samples correspond to surface material from dry arroyos sieved to 80 mesh, which were further digested with *aqua regia* and analyzed for 64 elements using induction coupled plasma mass spectrometry (ICP-MS).

The data consisted of 1,016 points scattered throughout the area (Fig. 1a). Using standard procedures (Breckenridge and Crockett, 1995) the data were separated into (a) background and (b) enriched concentrations. Natural background concentrations corresponded to values below 80% percentile for each element, while values larger than the 80% percentile were considered enriched concentrations. Within the enriched concentrations, values larger than the average plus two standard deviations were further labeled as anomalous values. ArcView (GIS) was used to plot these concentrations and the resulting maps were analyzed for specific patterns.

Results and Discussion

Although enriched concentrations clustered around mine tailings and mineral deposits mined for those particular metals, concentration patterns showed much more than just the enrichment near their mining source. For example, from the 1,016 original data for Cu, 822 fell below natural background concentration category, 205 were enriched concentrations and 51 points were anomalous. Most of the anomalous points (Cu of 46.6 to 402 ppm) were located in the vicinity of mine tailings of sulfide mines reportedly containing Cu-bearing ores. The pattern for natural background and enriched concentrations was however very different from the scattered pattern expected from an area with similar geology throughout, instead, there was an almost complete separation of enriched concentration in the southern portion of the study area and background concentration in the northern part (Fig 1b).

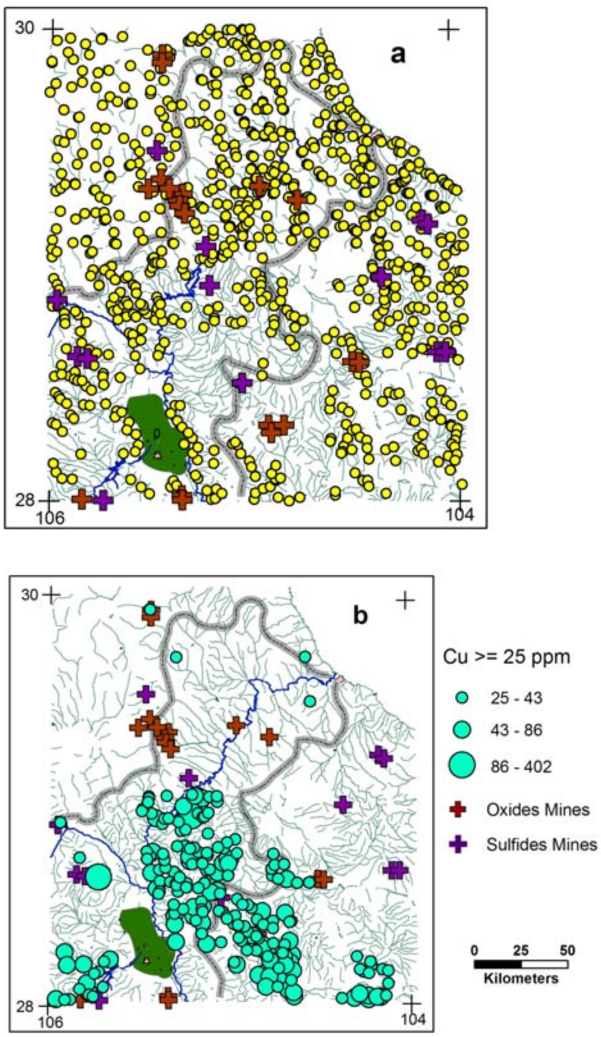

Figure 1. (a) Location of sampling points within the study area, and (b) distribution of enriched concentrations (> 25 ppm). The green area in the SW part of the map represents irrigated land, and the grey line represents the Rio Conchos basin boundary.

Although the concentration patterns for Pb and As were different to the patterns obtained for Cu, they all had in common the clustering of anomalous concentrations around mine tailings.

Conclusions

Geochemical data sets are a useful tool in determining contaminant sources and their distribution; they are versatile and relatively easy to use in environmental characterization studies. Concentration maps embody a more useful reference than sole numbers, as they contain expected natural background concentrations corresponding to their particular location, which may yield more meaningful comparisons among concentrations under presumably contaminated conditions.

References

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