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Procedia Earth and Planetary Science 7 (2013) 171 – 174

Procedia
Earth and Planetary Science

Water Rock Interaction [WRI 14]

Antimony dispersion at abandoned mines in Sardinia, Italy

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Abstract

Aqueous Sb may result from both natural and human processes. The World Health Organization has established a guideline value of 20 µg/L Sb for drinking water. Concentrations of Sb above drinking water standards may occur in water draining abandoned mines. The Sb occurrence in water and potential dispersion in the atmosphere were investigated at Su Suergiu (Sardinia, Italy). The Su Suergiu Sb ores were exploited between 1880 and 1980, with mining and processing residues abandoned on site. Surface waters downstream of the mine show high concentrations of Sb (up to 1500 µg/L). Contamination extends several km downstream of the mine and affects the Flumendosa River, water from which is used for irrigation and domestic purposes. Dust materials deposited on leaves collected in the mine area contain 70 µg/kg Sb, as compared to 7 µg/kg Sb observed on leaves collected on upstream slopes.

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Keywords: aqueous antimony; antimony dispersion; mine water; abandoned mine; Sardinia

1. Introduction and study area

Antimony is categorized as a non-essential element for plants, animals and humans, while it is listed as a priority pollutant by the US Environmental Protection Agency and the World Health Organization. The mobility, bioavailability and toxicity of Sb depend on its speciation. Aqueous Sb may occur as antimonous and antimonic acids with related species, respectively under reducing and oxidizing conditions. However, thermodynamically unstable Sb species may occur under different redox conditions, suggesting that the kinetics of redox reactions may play a significant role in defining the impact and fate of Sb in the environment [1]. Atmospheric Sb compounds may derive from waste incineration, fossil fuel combustion, ore smelting, and road traffic [2], with Sb in airborne matter estimated at ng/m^3 level, and higher values in urban areas [3].

This study aims to investigate the occurrence and speciation of Sb in waters impacted by past Sb mining and to evaluate the Sb dispersion in the atmosphere. The study area is located at Su Suergiu (SE

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Selection and/or peer-review under responsibility of the Organizing and Scientific Committee of WRI 14 – 2013
doi:10.1016/j.proeps.2013.03.008

Sardinia, Italy). The Sb-W deposits hosted in Paleozoic black schists and limestone were exploited since 1880 until mine closure in 1960. A foundry was active from 1882 to 1987. The most abundant minerals are antimonite, scheelite, arsenopyrite, pyrite, with calcite and quartz in the gangue. Slag and tailings (87% of dumped materials) and waste rocks were dumped nearby the mine plant (Fig. 1). Mining and processing residues are estimated at about 66,000 m^3 [4]. Leptosols are the main soils in the area, and Cambisols occur on slopes and colluvial deposits. Mean annual precipitation is 670 mm, and temperature 16 °C. Springs usually have flow <0.1 L/s. The flow of streams varies depending on rainfall. Untreated drainage from Su Suergiu flows into the Rio Ciurixeda stream, a tributary of the Flumendosa River that supplies water for agricultural and domestic uses.

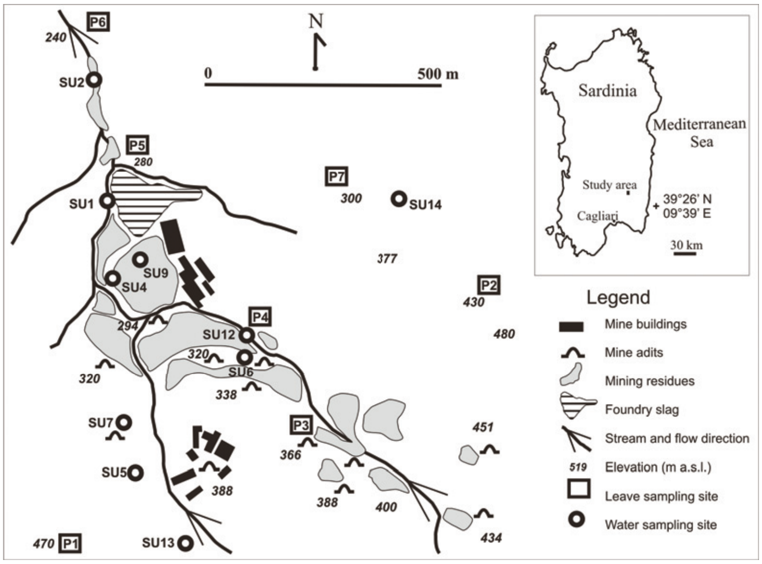

Fig. 1. Map showing the Su Suergiu mine area and location of sampling sites

2. Methods

Water and vegetation samples were collected in spring 2012. Water samples consist of springs, mine drainage, and water draining slag materials (Fig. 1). The physical–chemical parameters and alkalinity were measured on site; water was filtered (0.45 µm) and acidified to 1% HNO_3 for metal analysis and total Sb by quadrupole ICP–MS using Rh as internal standard. A filtered aliquot was acidified to 1% HNO_3 and 0.2% (L+) tartaric acid for Sb(III) analysis by adsorptive stripping voltametry (Metrohm 797 VA Computrace, hanging Hg drop electrode in 0.6 M HCl). Sb(V) was calculated subtracting Sb(III) from total Sb. To evaluate the potential Sb dispersion in the atmosphere, 23 leaf samples (*Pistacia lentiscus*) were collected (Fig. 1) in PE bags and stored at 4 °C. In the lab, 25 g of leaves were washed with 250 mL of 0.01 M HCl, used as a proxy of rainwater, and shaken for few minutes. The solution was filtered at 0.4 µm, reduced to 50 mL final volume, acidified with HNO_3 and analyzed by ICP-MS.

Results

Table 1 reports values of flow, pH, redox potential (Eh), electrical conductivity (EC), dominant

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