



Antimony and arsenic behaviours in soils from three abandoned gold mining areas in northern Portugal

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The Valongo anticline located 18 km at East of Porto is characterized by the occurrence of several gold deposits, which were exploited until the end of the nineteenth century. This anticline comprises Cambrian to Carboniferous metasediments. The Cambrian schist-graywacke complex crops out in the western limb of the anticline and is intersected by several Sb-Au quartz veins, mainly Montalto and Tapada. At the eastern limb of the anticline, As-Au quartz veins cut Ordovician black slates and were exploited at the Banjas mine. The Sb-Au quartz veins contain mainly quartz, arsenopyrite, pyrrhotite, pyrite, marcasite, sphalerite, chalcophyrite, galena, gold, tetrahedrite, jamesonite, plagioclase, berthierite, stibnite, antimony and carbonates. The As-Au quartz veins consist of quartz, arsenopyrite, pyrite, pyrrhotite, cobaltite, glaucodote, sphalerite, boulangerite, tetrahedrite and siderite. Stibnite and arsenopyrite are the most abundant sulphides in Sb-Au and As-Au quartz veins, respectively. Therefore, antimony and arsenic are potential contaminants in the surrounding environments of these old mines. The principal component analysis (PCA) was applied to organic matter, pH, cation exchange capacity, clay size particle and reducible, oxidizable and aqua regia Fe, Mn, As and Sb concentrations obtained by the BCR method in 29 soil samples. The PCA shows a substantial distinction between Sb and As behaviours in soils from the old mining areas of Montalto, Tapada and Banjas. The arsenic concentration ranges between 16.98 mg/kg and 1116 mg/kg, whereas the Sb concentration ranges from 6.4 mg/kg to 21775 mg/kg. The antimony is statistically more correlated with Fe and Mn in the oxides fraction, whereas As in the reducible fraction depends on pH values. Moreover, Fe and Mn concentrations in the oxidizable fraction are highly correlated with the organic matter, suggesting that pyrite, the main host mineral of Fe, was probably totally altered. However, the As concentration in the oxidizable fraction is in a distinct component axis, suggesting possible association to arsenopyrite or amorphous sulphides. The bioavailable concentrations (exchangeable + reducible fractions) of Sb in soils from the three old mining areas range from 2.35 mg/kg to 112.81 mg/kg, whereas those of As range from 1.81 mg/kg to 58.75 mg/kg.