Arsenic release from Argentinean volcanic glass and ashes

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Volcanic glass and ashes are the main sources of arsenic in the loess sediments of the Argentinean Pampean plain [1]. Dissolution of these volcanic materials is associated with the high arsenic content in groundwater of the Pampean aquifer, which exceeds the maximum 0.01 mg/L level allowed by the World Health Organization (WHO). The present study aims at better understanding how arsenic is released during dissolution of these materials.

Flow-through experiments at room temperature were carried out to study the dissolution kinetics of 1) one volcanic glass contained in the loess, 2) two volcanic ashes from Caulle and Chaiten volcanoes and 3) an ash layer from Tres Arroyos, Buenos Aires province. Glass dissolution was studied at pH 2-12 while that of the three ashes was studied at pH 10. All samples contained plagioclase (32-65 wt%), quartz (3-28 wt %) and an amorphous Si-rich phase (22-65 wt%). The release of Na, K, Ca, Si, Al and As was monitored over time, and the steady-state concentrations of Si were used to calculate the dissolution rates of the glass and the ashes. Temporal variation of the stoichiometric ratios (Na/Si, Ca/Si, Al/Si and As/Si) was used to determine the occurring reactions.

Experimental results and 1D reactive transport modeling showed that (1) volcanic glass dissolved faster at pH 2 and 12 than at the other pH values; (2) at pH 2, the steady-state aqueous Al/Si ratio was ≈ 0.43 (oligoclase) whereas at pH 10-12, the Al/Si ratio was lower (0.18-0.25), suggesting incongruent dissolution of the plagioclase with a preferential release of structural Si over Al; (3) the ashes dissolved similarly at pH 10 and the dissolution rates were comparable to that of glass at pH 10 ($\approx 10^{-12}$ mol m^{-2} s^{-1}); (4) an initial fast release of Na, K and Ca from the amorphous phase was attributed to cation exchange between these cations and the monovalent cations of the electrolyte solutions; (5) the release of As took place during dissolution of the amorphous material, such that the As/Si ratio was $\approx 10^{-4}$. This indicates that weathering of Pampean loess (glass) and ashes significantly contributes to the high As content in the groundwaters of the Pampean aquifers.

[1] Nicolli et al. (1989) Env. Geol. Water Sci. 14:3-16.