Geochemical and isotopic evolution of thermal water of São Miguel, Azores (Portugal)

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Thermal water of São Miguel has been investigated to decipher its geochemical and isotopic evolution as a case study for the development of a geothermal system in an evolving basaltic ocean island. Besides water, precipitates and local volcanic rocks were sampled for analyses. From isotope, geochemical, microstructural and mineralogical data a conceptual model for water evolution in São Miguel (Furnas, Fogo, and Ferraria) was developed.

Thermal discharges were divided into springs (up to 75 °C) and boiling pools, and classified by dominant dissolved ions in Na-SO_4, Na-HCO_3 and Na-Cl types. In Furnas, at higher temperature the concentrations of $Si(OH)_4$, K^+ and Sr^{2+} increased through intensive alteration of basaltic rocks, whereas in contrast Al^{3+} and $\sum Fe$ concentrations decreased by precipitation of e.g. alunite. In Fogo, at higher altitude in particular CO_2 rich water at $T \approx 20$ °C occurs. In this case the extent of basaltic rock leaching rather depends on uptake of volcanic CO_2 than on temperature. HCO_3^- concentration and its isotopic composition ($\delta^{13}C(DIC) = -5 \pm 3$ ‰ V-PDB) reflect evolved CO_2 uptake and subsequent leaching progress. High SO_4 concentration of up to 16.5 mmol L^{-1} with $\delta^{34}S(SO_4)= 0.35 \pm 0.3$ ‰ (V-CDT) are reflecting magmatic origin which mainly controls water chemistry of boiling pools of both Fogo and Furnas. Lowest $\delta^{34}S(SO_4) = -3.7$ ‰ (V-CDT) are accompanied by stromatolite-like microstructures in the precipitates. In Ferraria water is discharging from a basal aquifer and belongs to the Na-Cl type, where stable hydrogen and oxygen isotopes reveal mixing of meteoric and sea water. The molar Mg/Ca ratio (0.77) of all thermal discharges reflects leaching of analysed local basalt (Mg/Ca ≈ 0.78).