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Silicon isotopes fractionation in meteoric chemical weathering and hydrothermal alteration systems of volcanic rocks (Mayotte)

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Low temperature chemical weathering fractionates silicon (Si) isotopes while forming secondary silicates. The Si fractionation ranges of high temperature secondary phyllosilicates formed in hydrothermal alteration environments have not been investigated to date. Several parameters, including temperature, reaction rates, pH, ionic concentrations in solution, precipitation/dissolution series or kinetic versus equilibrium regime are not the same in hydrothermal alteration and surface weathering systems and may lead to different fractionation factors. In this work, we analyzed Si isotopes in these two types of alteration conditions in two profiles sampled on the volcanic island of Mayotte. In both profiles, Si-bearing secondary mineral was kaolinite.

Both profiles showed ^{30}Si depletion as a function of the degree of alteration but each with a distinct pattern. In the meteoric weathering profile, from the bottom to the top, a gradual decrease of the δ^{30}Si from parent rock (-0.29 $\pm$ 0.13 ‰) towards the most weathered product (-2.05 $\pm$ 0.13 ‰) was observed. In the hydrothermal alteration profile, in which meteoric weathering was also superimposed at the top of the profile, an abrupt transition of the δ^{30}Si was measured at the interface between parent-rock (-0.21 $\pm$ 0.11 ‰) and the altered products, with a minimum value of -3.06 $\pm$ 0.16 ‰.

At the scale of Si-bearing secondary minerals, in the chemical weathering system, a $\Delta^{30}Si_{kaol-parentrock}$ of -1.9 ‰ was observed, in agreement with results in the literature. A low temperature kinetic fractionation $^{30}\varepsilon$ of -2.29 ‰ was calculated using a simple steady state model. However, an unexpected $\Delta^{30}Si_{kaol-parentrock}$ of -2.85 ‰ was measured in the hydrothermal alteration site, pointing to possible mechanisms linked to dissolution/precipitation series and/or to ionic composition of the solution as the main controlling factors of fractionation in hydrothermal conditions.

At the scale of the profiles, both δ^{30}Si bulk rocks showed linear correlations with the SiO_2:Al_2O_3 ratios, suggesting an alternative alteration index based on Si isotopic composition.