

New developments in Li-Chronometry: Determining timescales of fluid-rock interaction

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Fluid-rock interactions occur on scales ranging from submicron to tens of kilometres. They play a key role in controlling mineral stability, plate dynamics, and element cycling by changing petrophysical properties and chemical composition of the involved rocks. Absolute ages of the reaction products can be obtained using conventionally applied radiogenic dating techniques, however, constraining timescales of individual processes represents one of the key challenges in solid Earth science today. To quantify the duration of relatively short-lived processes Li-chronometry is shown to be very effective.

Li-chronometry relies on fitting numerical simulations to Li variations measured in preserved mineral assemblages that are clearly formed by a fluid-rock interaction process.

Successful application of Li chronometry has to involve (1) correct interpretation of the mineral and rock record of key outcrops, (2) precise and accurate measurements of Li isotope composition and concentration, and (3) an adequate model including the essential physics to simulate the evolution Li concentration and isotope composition.

We present new developments to numerical simulate fluid-mediated transport that result in changes of the mineral assemblage of the affected rock. Our model is based on conservation of mass, concentration and fluid momentum. The initial background porosity is determined experimentally and the transient effects on the porosity evolution are directly linked to the mass transport and the change in the mineral assemblage by chemical reactions. The fluid-rock partition coefficient of Li changes due to the continuous change of the assemblage of the rock forming minerals in the model. This allows us to use Li as a passive recorder of the fluid-rock interaction accompanying changes of the rock record. Importantly, Li represents a trace-element in the solid and the fluid, Li fluid-solid exchange is controlled by dissolution-precipitation processes and Li transport occurred exclusively in the fluid. By fitting the simulated to the observed Li profiles the duration of the fluid-rock interaction process is determined.