



Li-chronometric constraints on the duration of fluid-rock interaction

Timm John (1), Andreas Beinlich (2), Stephan Taetz (3), Yuri Podladchikov (4), and Tomas Magna (5)

(1) Freie Universität Berlin, Institute of Geological Sciences, (timm.john@fu-berlin.de), (2) Curtin University, The Institute for Geoscience Research, (3) Universität Münster, Institut für Mineralogie, (4) University of Lausanne, Institut of Earth Sciences, (5) Czech Geological Survey

Fluid-rock interactions occur on a wide range of scales from μm to km controlling mineral stability, plate dynamics, and element cycling. The controlling mechanism is the fluid-induced dissolution-precipitation reaction that strongly affects petrophysical properties and chemical composition of the involved rocks. Thus, fluid-rock interaction facilitates strain localisation and tectonic responses to plate motion, element mobilisation and formation of ore deposits as well as melt formation in volcanic arc settings. In many cases, the absolute age of the reaction products can be obtained using conventionally applied radiogenic dating techniques, whereas constraining presumably short reaction durations represents one of the key challenges of the current solid Earth science. Lithium chronometry is based on fast diffusivity of Li, and is a novel tool to obtain information on the duration of fluid flow and fluid-rock interaction.

We applied Li chronometry to three different case studies: Two fossil high-pressure fluid pathways and their associated reaction haloes formed at about 70 km depth during subduction of coherent oceanic slabs (Chinese Tianshan and New Caledonia). Both systems represent localized fluid flow paths with formation of reaction selvages consistent with diffusion-dominated metasomatic element exchange controlled by chemical gradients. The third case study deals with a large-scale mid crustal reaction front propagation of soapstone replacing a serpentinite (Norway). In this case advective-diffusive transport resulted in the formation of a sharp mineral replacement front driven by a strong chemical gradient between the reactive fluid and the infiltrated rock. The commonality among the three case studies is that Li represents a trace-element in the solid and the fluid where Li fluid-solid exchange has been controlled by dissolution-precipitation processes and Li transport occurred exclusively in the fluid.

Detailed textural observations coupled with Li-diffusion modelling suggest that:

1. Local thermodynamic equilibrium is a valid assumption for fluid-mediated processes at high fluid-rock ratios and elevated temperatures.
2. Outcrop scale fluid-induced replacement reactions occur on time-scales of tens to thousands rather than millions of years.
3. Strain localization, ore deposit formation, and large-scale element mobilization might occur on time-scales that are significantly shorter than inferred by geodynamic considerations.
4. Transient, reaction-induced porosities may reach values that are 5-10 times greater than those in non-reacted country rocks.