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Modeling serpentinite dehydration on multiple scales constrained by field observations

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Dehydration of serpentinites in subduction zones plays a major role in Earth's deep water cycle. The fact that there is still water present at the Earth's surface indicates an efficient fluid release mechanism that is able to keep up with transport of water into the mantle by subduction. Rock dehydration itself is a multi-scale process that spans several orders of magnitudes in both time and spatial scales.
Plümper et al. (2016) showed that on small scales (µm-mm) dynamic porosity generation and fluid flow is mainly controlled by intrinsic chemical heterogeneities in the rock. However, field observations indicate that on larger scales the process might be mechanically dominated by the formation of a channelized system of hydraulic fractures that form during pulsed fluid release which occurs on much shorter time scales. To get a better understanding of the multi-scale formation of a channelized fluid network a mathematically and thermodynamically valid model is needed that describes the process of rock dehydration crossing a range of scales over several orders of magnitudes. The project is therefore in collaboration with mathematicians as part of the DFG funded CRC 1114. As a first step we want to extend the model of Plümper et al. (2016) by considering chemical transport during reactive fluid flow and upscale it by one order of magnitude, from the mm- to the cm-scale.
In order to understand the chemical and structural heterogeneities in non-deformed serpentinites we mapped and sampled an outcrop in the Mirdita ophiolite in Albania. These serpentinites are still fully hydrated due to ocean floor serpentinization and show information about intrinsic heterogeneities of serpentinized mantle as it enters the subduction zone. We will use these data as input for the extended model that aims to simulate serpentinite dehydration in the downgoing slab.
We present the results of field work in the Mirdita ophiolite and the results of the preliminary extended and upscaled model. Geological mapping has been done on an outcrop scale as well as detailed mapping of representative units in order to get information about structural and lithological heterogeneities that might influence the formation of the dehydration vein network on large scales. The samples were then further studied by EDX mapping, XRF and detailed electron microscopy. Of special interest will be the coupling of the chemical and mechanical processes on different scales and what controls the transition from a chemically to a mechanically dominated system.

Reference

Plümper, Oliver et al. (Dec. 2016). "Fluid escape from subduction zones controlled by channel-forming reactive porosity".
In: Nature Geoscience 10.2, pp. 150-156. doi:10.1038/ngeo2865.