Goldschmidt 2023 Abstract
https://doi.org/10.7185/gold2023.19272

Temporary weakening during eclogite-facies shear zone formation by diffusional hydrogen influx and H_2O inflow (Holsnøy, Western Norway)

TIMM JOHN[1], LISA KAATZ[1] AND STEFAN SCHMALHOLZ[2]

[1]Freie Universität Berlin

[2]University of Lausanne, Géopolis

Presenting Author: timm.john@fu-berlin.de

Exposures on Holsnøy island indicate fluid infiltration through fractures into a dry, metastable granulite. This fluid infiltration caused a hydration of the granulite, triggered a kinetically delayed eclogitization, led to a temporary weakening during fluid-rock interaction, and to the formation of shear zones that widened during shearing. To better understand the link between deformation and fluid–rock interaction one cm-wide shear zone at incipient eclogitization was investigated.

Granulite and eclogite consist of garnet, pyroxene, and plagioclase. These nominally anhydrous minerals (NAMs) display increasing H_2O-contents from granulite to eclogite. Bowl-shape H_2O-profiles of garnet and pyroxene with lower H_2O-contents in grain cores and higher at the rims indicating a prograde water influx into the grains. Fluid-induced metamorphic equilibration induced the replacement of granulitic plagioclase by fine-grained hydrous albite-rich plagioclase, clinozoisite, kyanite, quartz, and amphibole leading to a bulk H_2O increase towards the shear zone. These results indicate a twofold hydration with different mechanisms to act simultaneously at different scales and rates. Fast, more pervasive hydrogen diffusion is recorded by NAMs that retain the major element granulite-facies composition. Contemporaneously, slower grain boundary-assisted aqueous fluid inflow enables element transfer and induced formation of new (e.g., hydrous) minerals.

To better constrain the hydration by both influx mechanisms and to estimate possible rheological interdependencies, a 1D numerical model of a viscous shear zone is utilized and validated using measured mineral phase abundance distributions and H_2O-contents of the NAMs. Both hydrations are described by a diffusion equation and affect the effective viscosity. Shear zone kinematics are constrained by the observed shear strain and thickness. The model fits the phase abundance and H_2O-content profiles when the hydrogen diffusivity is ~10 times higher than the diffusivity for aqueous fluid inflow. The observed shear zone thickness is reproduced when the viscosity ratio between dry granulite and deforming, re-equilibrating eclogite is $\sim10^4$ and that between dry granulite and hydrated granulite is $\sim10^2$. The results suggest relative shear velocities $<10^{-2}$ cm/a, hydrogen diffusivities of $\sim10^{-13\pm1}$ m^2/s, and a shearing duration of <10 years. The results of this study successfully confirm and emphasize the importance of hydrogen diffusion for shear zone widening and eclogitization.