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The distribution of the H_2O content in nominally anhydrous minerals and its effect on shear zone formation and widening (Holsnøy, West-Norway)

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High-grade granulites from Holsnøy in the Bergen Arcs (western Norway) underwent subduction during the Caledonian orogeny. They maintained a metastable state until fluid infiltration triggered the kinetically delayed eclogitization.
Field observations reveal an interconnected network of hydrous eclogite-facies shear zones surrounded by pristine unreacted granulites. The eclogitization is localized and controlled by deformation, fluid infiltration and subsequent fluid-rock interaction. In a first quantitative study we combined detailed field-mapping with numerical modelling to investigate the evolution of hydrous eclogite-facies shear zones. Although it is supposed that strain localizes within the shear zones, we were able to show that widening overcomes the effect of stretching during progressive fluid-rock interaction and strain accumulation. A continuous fluid infiltration has a strong positive effect on shear zone widening. Our conclusions suggest that either numerous repetitive pulses and/or a substantial amount of continuously infiltrating fluid is required to reproduce the observed structures.

Mass balance considerations reveal that the eclogitization of the granulite did not result in significant compositional changes, hence the fluid composition was quickly rock buffered. To better understand the link between deformation, mineral transformations, and fluid-rock interaction, we measured H_2O contents incorporated in the form of OH groups in nominally anhydrous minerals (NAMs). Garnet, pyroxene, and plagioclase were investigated using Fourier transform infrared spectroscopy (FTIR) for OH contents, electron probe microanalyzer for element composition and scanning electron microscope to detect the distribution of the mineral phases. The quantity of IR-radiation absorbed is proportional to the concentration of OH groups and OH-stretching frequencies enable to discriminate between hydrous phases and hydrous components in NAMs. Results for garnet show: (i) compositional effects - the eclogite-facies, almandine-rich rims have higher water contents (Ø 60-90 µg/g) compared to the granulite-facies, pyrope-rich cores (Ø 10-25 µg/g), (ii) asymmetric water profiles - water contents increase towards the shear-zone, within one sample section from granulite to eclogite and in single garnet grains, therefore, (iii) the garnets represent good recorders of the fluid transport direction. The pyroxenes incorporate higher amounts of water (Ø 150-350 µg/g). Only tiny amounts of H_2O are stored in plagioclase (Ø 5-15 µg/g) before small clinozoisite needles form.