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H_2O contents in nominally anhydrous minerals and its effect on the formation of eclogite-facies, hydrous shear zones (Holsnøy, Western Norway)

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High-grade dry granulites of Holsnøy (Western Norway) were subducted during the Caledonian orogeny and reached eclogite-facies conditions at ~2 GPa and 700° C. However, they stayed in a metastable state until brittle deformation enabled infiltration of an aqueous fluid, which triggered the kinetically delayed eclogitization. Field observations reveal an interconnected network of hydrated eclogite-facies shear zones surrounded by unaltered and pristine granulites. The formation of these features is highly controlled by deformation, fluid infiltration and fluid-rock interaction.

At first, the shear zone evolution was analyzed to better understand the relation between strain localization within the shear zones and the progressive widening of these shear zones from cm- to m-wide thickness. The results showed that widening overcomes the effect of stretching during progressive fluid-rock interaction and strain accumulation, if either a substantial amount of continuously infiltrating fluid and/or numerous repetitive fluid pulses enter the system.

Therefore, investigations have been carried on the H_2O contents in nominally anhydrous minerals of the granulite and eclogite. The H_2O contents were measured using Fourier transform infrared spectroscopy. Garnet (grt), clinopyroxenes (cpx) and plagioclase (plg) have been measured with a close look on spatial repartition of OH at the grain scale and at the shear zone scale. The aim is to decode the link between fluid infiltration, mineral reaction, and deformation. There are no significant compositional changes between granulite and eclogite, which means that the fluid mainly worked as a catalyst without mass transfer beside H_2O. The analyses across a shear zone profile reveal three major observations: (i) average H_2O contents of the grt cores increase from granulite towards the shear zone (from 10 to 50 µg/g), (ii) average H_2O contents of the cpx increase, too (from 145 to 310 µg/g), (iii) the plg stores limited amounts of H_2O until a phase separation leads into an symplectites consisting of albite-rich plg (anhydrous) and clinozoisite (hydrous). The H_2O contents of the minerals are interpreted to be a result of two different diffusional mechanisms acting simultaneous at different spatial scales and rates. The H_2O increase in grt and cpx cores without mineral reaction is a result of hydrogen diffusion (H^+/H_2), which is much faster and pervasive than the porous influx of an aqueous fluid (H_2O), which,

contemporaneously, caused the formation of hydrous phases.

The above findings are combined in a 1D numerical shear zone model to reproduce the measured mineral chemical data and the respective H_2O-contents. The results shed light on the dynamic weakening processes caused by the influx of H+/H2 in combination with synkinematic mineral reactions.