Effect of volume changes on style of mineral reactions during mixed-volatile infiltration in ultramafic-mafic rocks from the Reinfjord lower crustal field laboratory

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This study demonstrates how the response of ultramafic lithologies to infiltrating H_20-CO_2 fluids depends on the primary mineralogy. This has major implications on fluid flow through the lower crust and upper mantle as mineral reactions control the permeability and rheology. The studied samples are from the hanging wall of a 2 kilometer-long transtensional shear zone in the Reinfjord Ultramafic Complex (RUC), part of the Seiland Igneous Province (SIP) in Northern Norway.

Fluid-rock interaction surrounding shear zones is highly variable and depends on bulk rock compositions. Thermodynamic modelling demonstrates that mineral reactions involving hydration and carbonation differ between dunitic rocks and the pyroxenitic dykes which intersect them. Alteration of dunitic rocks results in the formation of dominantly magnesite-anthophyllite-talc and talc-magnesite assemblages causing approximately 12% volume expansion. This results in a sharp reaction front contacts with the host rock. When the alteration zones cross the dunite-pyroxenite boundary the associated alteration has a more gradual boundary towards the unaltered rock and the alteration zone widens by approximately 40%. In contrast to the simpler dunite alteration assemblage, the pyroxenetic dykes are altered to a complex mixture of cummingtonite-anthophyllite, magnetite and chlorite. Additionally, orthopyroxene is completely pseudomorphed by a mixture of cummingtonite and magnetite, whereas olivine xenocrysts are partly preserved and surrounded by a magnesite-anthophyllite assemblage. Other, open cavity-like areas are filled by chlorite, amphibole, and Mg-MgCa carbonates, indicating volume reduction during alteration of the pyroxene.

Accordingly, dunite alteration effectuates a significant volume expansion, and are therefore only altered locally during seismic creep events. The pyroxenites are near volume neutral throughout interaction with the same fluids, and are thus more homogeneously altered. The formation of chlorite in hybrid compositions, such as the dykes in the lower crust, may create weak permeable zones that are consequently exploited as pathways for fertile mantle fluids and will hence also be the locus of ore bearing fluids moving to the upper crust. Increased understanding of fluid mediated metamorphism increases our current knowledge on fluid flow and strain localization in the lower crust.