



COH-fluid driven carbonation of serpentinites and spinel peridotites within the forearc region of the mantle wedge and in the subducting slab

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Carbonation of serpentinite and spinel peridotite in the forearc region of the mantle wedge in subduction zones and within the subducting slab by CO₂-bearing aqueous fluids released during subduction were investigated in this study. We show that this process is potentially an efficient mechanism to sequester CO₂ in the mantle wedge and subducting slab, which may have important implications for estimates of the carbon fluxes into the deep earth.

Piston cylinder experiments were performed using natural, powdered antigorite with CO₂+H₂O fluids at 1 and 2 GPa and temperatures ranging from 550 °C to 750 °C. The equilibrium fluid compositions were measured by piercing the capsules recovered from piston cylinder experiments and introducing the released fluid into a gas chromatograph. The resulting mineral assemblages and fluid compositions were compared with the results of thermodynamic modelling of the antigorite-CO₂-H₂O system. Additional piston cylinder experiments were performed at 1.5-2.5 GPa and 375-700 °C using cylindrical samples cored from natural serpentinite and spinel peridotite in the presence of COH-fluids. These experiments include a time series and aimed to simulate fluid-rock interactions allowing investigation of fluid flow mechanisms and reaction rates. We compare our experimental results with field observations of large scale carbonation of subducted ultramafic rocks within the Western European Alps.

In the experiments using powdered serpentinite, the formation of magnesite + chlorite together with quartz, quartz + talc or talc with progressive carbonation was observed at 1-2 GPa and 500-650 °C. In the experiments using serpentinite cores, textural evidence shows enhanced fluid migration along fractures and the percolation of the reaction interface with time (and progressing reaction) from the core's surface towards the center of the core. This forms distinct and sharp boundaries between zones of quartz + magnesite and talc + magnesite. Clear distinguishable reaction zones and similar mineral assemblages were also formed in the pseudomorphic replacement of primary phases in the peridotite core experiments. Carbonation occurs rapidly even in experimental samples with natural grain sizes, textures and foliation of the serpentinite and peridotite cores. For example, ~5 wt%, ~20 wt%, ~60 wt% and ~75 wt% of the original serpentinite-core is replaced by magnesite and talc after 12 h, 24 h, 96 h and 192 h at 2 GPa and 600 °C. The findings of our study have important implications for estimating the deep Earth's carbon fluxes as the mantle wedge may become, over time, a significant reservoir for carbon. Additionally, carbonation of ultramafic rocks within the subducting slab may contribute to C-transfer to the deeper mantle.