Goldschmidt 2021 Abstract
https://doi.org/10.7185/gold2021.5662

Iron redox and potential for hydrogen production during serpentinization of fine-grained lherzolites : Results from a 417-day batch hydrothermal experiment

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H_2-rich fluids are measured in hydrothermal vents along slow oceanic spreading centers. H_2 production is interpreted as resulting from the oxidation of Fe^{2+} from mantle minerals to Fe^{3+} hosted by secondary minerals during serpentinization. The nature of secondary Fe^{3+}-bearing phases depends on reaction paths and thus on PTX conditions. To better constrain the contribution of the mineralogy and structure of the protolith on the distribution and speciation of iron during incipient serpentinization, we carried out a 417 day (10 000 h) hydrothermal experiment (30 MPa, 270°C) with two variably mylonitized lherzolite cores (diameter 6 mm x length 6 mm; poorly serpentinized Turon lherzolite [1]) and artificial seawater. The structure of the ultramylonite and protomylonite cores were characterized using micro-CT before and after experiment. The distribution and speciation of iron in the protolith and reacted samples were measured by μ-XANES spectroscopy at the Fe *K*-edge (SOLEIL, France).

Micro-CT analyses of the protomylonite show the development of a network of serpentine veinlets (10-20 μm thick) during the experiment, but no evidence of brucite or magnetite. Secondary serpentine veins stem from the rare comb-shaped serpentine veinlets characterizing the protolith. 10% of the olivine was converted into serpentine, indicating serpentinization kinetics ~50 times slower than for hydrothermal experiments realized on peridotite powders at the same conditions. In contrast, preliminary micro-CT analyses of the ultramylonite show no evidence of serpentinization, indicating that ultramylonites did not develop a connected porosity and/or crack network in contrast to protomylonites.

The protomylonite secondary serpentine is Fe-rich (Fe/Mg = 0.1-0.17) and has high $Fe(III)/Fe_{total}$ (0.6-0.8) compared to initial serpentine (Fe/Mg = 0.12; $Fe(III)/Fe_{total}$ = 0.4-0.55). Preliminary data indicate that $Fe(III)/Fe_{total}$ decreases towards the centre of the core, suggesting a control of fluid flow on iron distribution and speciation. Our results indicate that, during incipient serpentinization, iron is concentrated in serpentine that, in turn, control the bulk Fe^{3+} budget and hydrogen production.

Tichadou, C., Godard, M., Muñoz, M., Labaume, P., Vauchez, A., Gaucher, E., Calassou, S., 2021. Mineralogical and geochemical study of serpentinized peridotites from the North-Western Pyrenees: new insights on serpentinization along a magma-poor continental passive margin. Submitted to Lithos.