Tracking serpentinization reactions *in situ* using synthetic fluid inclusions in ultramafic minerals

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Serpentinization is an important geological process that occurs where ultramafic rocks are exposed to fluid circulation in the oceanic and continental crusts. Despite much recent attention, aspects of serpentinization such as the order of reactions, their timing and the direction in which they occur are still a matter of considerable debate in the literature. We used the synthetic fluid inclusion technique to trap fluids of known composition at known P-T conditions in olivine crystals to follow in-situ serpentinization reactions in a closed system at low water/rock ratios. Pre-fractured olivine crystals were loaded into platinum capsules along with a H_2O-NaCl-$MgCl_2$ fluid of seawater concentration (3.5 wt.%) and Na/Mg ratio of 8:1, then welded shut [1]. The loaded capsules then were placed into high-pressure vessels, and P-T were increased to 5.6 kbar and 600 ºC for 21 days. After trapping of fluid inclusions at the selected conditions in the samples, the inclusions were examined petrographically before the samples were placed into a furnace at ~280 ºC and 1 atm.

Preliminary results show that serpentinization reactions start after a few days in some of the fluid inclusions. Mineralogy was monitored by Raman analysis, and we observed the formation of brucite and serpentine. After 28 days, some of the fluid inclusions had consumed nearly all of the fluid, leaving the cavity filled with brucite, serpentine and halite. Small fractures in the fluid inclusions reveal significant volume change during serpentinization. In at least one case, H_2 was detected in the fluid inclusion, showing that the reducing conditions inside the fluid inclusion are similar to what occurs in nature. However, no magnetite was observed in any of the fluid inclusions based on Raman analysis, suggesting that the reaction $2(FeO)_{rock} + H_2O \longrightarrow (Fe_2O_3)_{magnetite} + H_2$ did not occur, and that Fe^{3+} may instead be incorporated into serpentine or another phase. This observation concurs with thermodynamic calculations and observations of natural samples in which magnetite is formed preferentialy by a secondary reaction of brucite and serpentine with higher fluid/rock ratios [2, 3]. Current experiments and thermodynamic modelling are being conducted in olivine, enstatite and diopside to constrain the rate of reaction of the trapped H_2O with hosts, to better understand these reactions and their overall implications of the serpentinization processes.

[1] Bodnar & Sterner, 1987, *Hydrothermal experimental techniques* (ed. G.C. Ulmer and H.L. Barnes) 423-457. [2] Bach *et al* 2006, *Geophysical Research Letters* **33**, L13306
[3] Frost & Beard, 2007, *Journal of Petrology* **48**, 1351-1368