# The role of trace element chemistry in controlling water incorporation in San Carlos olivine

P.M.E.Tollan[1,2] H.St.C. O'Neill[1]

[1]Research School of Earth Sciences, The Australian National University, Australia
[2]Institut für Geologie, Universität Bern, Switzerland, peter.tollan@geo.unibe.ch

Numerous experimental studies have demonstrated that the solubility of water in forsterite is substantially enhanced by addition of certain trace elements. Despite the clear relationship in simple synthetic systems, some studies on natural olivines have concluded that the ability of trace elements to influence water incorporation is minimal. We have attempted to reconcile this discrepancy by hydroxylation experiments on pre-annealed crystals of San Carlos olivine with concentrations of trace impurities that span a range typical for upper mantle olivine.

Six optically clear crystals of San Carlos olivine ($Fo_{89}$ to $Fo_{92}$) were cut into orientated cubes and annealed at 1400 °C at oxygen fugacity FMQ +1 for 24 hours. The cubes were then sealed inside silver capsules with water and run in a piston-cylinder apparatus for 72 hours at 800 °C and 15 kb, allowing H to diffuse into the crystal and decorate existing point defects. After quenching, the cubes were extracted, double-polished and analysed by FTIR and LA-ICP-MS.

Total water contents calculated using the entire OH-stretching region show no clear relationship with composition. However, when the absorbance beneath individual bands is compared to composition, distinct relationships are found. In particular, the intensity of bands at 3572 $cm^{-1}$ and 3525 $cm^{-1}$ correlate well with the Ti content, whilst bands between 3400 $cm^{-1}$ and 3300 $cm^{-1}$ show a positive correlation with Cr/Na. There were no correlations between any of the band intensities and Al concentration.

The relationship with Ti is of particular significance, since formation of this hydrous defect results in the generation of Si vacancies and thus weakening of the olivine structure [1]. The substantial range of Ti contents and associated hydrous defect concentration between olivine crystals extracted from a single locality suggests that interaction of fluids with typical upper mantle peridotite may induce substantial weakening effects over length scales much smaller than typically considered. Accurate models of total mantle water content and rheology must therefore take this small-scale compositional variability into account.

[1] Faul UH et al. (2016) Earth Planet Sci Lett 452, 227-237.