Crystallographic incorporation of hydrogen in ringwoodite

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The transition zone (TZ) is believed to be the primary destination of subducted water [1], with the main TZ minerals (wadsleyite and ringwoodite) capable of holding up to ~ 3 wt.% H_2O in their structures'. Observations of high attenuation and elevated conductivity suggest some areas of the transition zone are hydrated [2,3]. Combined with the observation of ~ 1.4 wt% H_2O in a diamond-hosted ringwoodite inclusion [4], it is probable that the transition zone is at least regionally, if not globally, "wet".

The presence of water can induce partial melting, alter chemical partitioning and drastically change the strength of rocks. The detailed effect of water's presence in the TZ will strongly depend on hydrogen's incorporation mechanism, i.e. exchange with Si^{4+}, Mg^{2+}, Fe^{2+} cations or coupled substitution with Fe^{3+} in ringwoodite. Recent developments in neutron single-crystal Laue diffraction now allow measurements on crystals smaller than 0.1 mm^3 [5]. Here we quantitatively study the incorporation of hydrogen in a synthetic iron-bearing ringwoodite. A multi-technique approach, with independent determination of chemistry, ferric iron content, water content and structure via x-ray and neutron diffraction allows a detailed study of the hydrous ringwoodite structure and the incorporation mechanism of water throughout Earth's TZ.

(1) Bercovici et al. (2003) Nature 425, 39
(2) Zhu et al. (2013) EPSL 381, 1
(3) Kelbert et al. Nature 460, 1003
(4) Pearson et al. (2014) Nature 507, 221
(5) Purevjav et al. (2016) Sci. Rep. 6, 34988