The effect of hydration on the elastic properties of ringwoodite at transition zone pressures

Kirsten Schulze*[1], Hauke Marquardt[1], Alexander Kurnosov[1], Takaaki Kawazoe[1], and Tiziana Boffa Ballaran[1]

[1]Bayerisches Geoinstitut, University of Bayreuth (BGI) – Bayerisches Geoinstitut Universität Bayreuth 95440 Bayreuth, Germany

Abstract

Mineral physics experiments have shown that ringwoodite can incorporate significant amounts of hydrogen into its crystal structure. Since ringwoodite is considered to be the most abundant mineral in the Earth's transition zone below 520 km depth, this opens the possibility for the presence of large amounts of water-equivalents in the mantle. This hypothesis is supported by the detection of _˜1.4 wt% H20 in a mantle ringwoodite found as a diamond inclusion (Pearson et al. 2014). The actual amount of 'water' in the transition zone, as well as its spatial distribution are still controversially discussed. A promising way to detect and map hydration of the transition zone is based on seismological observations, as mineral physics findings predict a significant reduction of seismic wave velocities of ringwoodite upon hydration. However, differences in predicted pressure effects complicate a reliable quantification of this effect at mantle transition zone pressures and temperatures, precluding any conclusive estimate of the hydration state of the transition zone.

Here we report results of an extensive HP/HT single-crystal Brillouin spectroscopy and X-ray diffraction study performed on four samples of ringwoodite with a Fo90 or Fo100 composition and a hydration state of 0.44 - 3.40 mol/L, equivalent to 0.21 - 1.71 wt% H2O.

To ensure identical experimental conditions and minimize relative uncertainties, all four samples were loaded in the same pressure chamber of a diamond anvil cell. Brillouin spectroscopy and X-ray diffraction were performed up to a pressure of 22 GPa. Further experiments were carried out up to 630 K temperature at pressures of the transition zone.Our comparative study indicates that the effect of hydrogen on the elastic properties is significantly smaller than predicted by previous studies. In particular, a reduction of the effect of hydration with increasing pressure is observed. At pressures equivalent to the lower transition zone, the velocity reduction caused by 2 mol/L of water is less than 1%.

For a pyrolitic mantle composition, ringwoodite is expected to constitute _˜56% by volume. Therefore, given the small effect of hydration on the elastic properties of ringwoodite, even large amounts of water in the transition zone mantle might be seismically indistinguishable from an anhydrous mantle.

*Speaker

sciencesconf.org:hpmps-9:159504