Sound Velocities of the Earth's Transition Zone Minerals

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Earth's mantle transition zone from 410 to 660-km depth exhibits seismic signatures reflecting thermo-chemical perturbations, including displaced depths of the nominal 410-km and 660-km discontinuities, the depth interval of the 410-km discontinuity, as well as lateral velocity variations compared to reference models. These observed anomalies have been proposed to correlate with the possible presence of H_2O and thermal effects because the cold subducted slabs may transport H_2O to the transition zone. Elastic properties of the major constituent minerals at relevant high pressure-temperature (*P-T*) conditions are crucial for understanding the mineralogical and geothermal models, water budget, and seismic velocity structures of the region. To understand the effects of high P-T and hydration on the sound velocities of major mantle minerals and to constrain the mantle's H_2O budget, we have measured the single-crystal elastic moduli of hydrous and nominally anhydrous iron-bearing mantle minerals using Brillouin light scattering combined with X-ray diffraction in an externally-heated diamond anvil cell up at relevant P-T conditions of the mantle. Our results on hydrous ringwoodite with 1.1 wt.% H_2O show a strong reduction by hydration in the elastic moduli at room temperature and a significant net effect of temperature and hydration on the elastic moduli at high pressures. Results on Fe-bearing minerals show that addition of iron does not have a strong effect on sound velocities at high P-T. These results are applied to quantify the effect of thermal perturbations as well as hydration on the seismic structures of the transition zone. Here we will address how the results can provide crucial constraints on the transition zone water budget that is essential for understanding the global water circulation. Specifically, our results indicate that the observed seismic velocity anomalies and related depth depression of the 660-km discontinuity could be attributed to thermal variations together with the presence of ~0.1 wt.% H_2O.