Elasticity of hydrous wadsleyite at high pressure and temperature: Constraint on water content in the mantle transition zone

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The water content within the mantle transition zone (MTZ), which is important to understand the dynamics and evolution of Earth, is still debatable. The elasticity of olivine and its hydrous polymorphs is critical for us to constrain the water content in MTZ. Here we calculated the elastic properties of hydrous wadsleyite at high temperature and pressure using first-principles calculations. The presence of water in wadsleyite decreases significantly its density and sound velocities. Our results agree well with available experimental data. This calculation and previous works [1,2] provide high-precision elasticity and density data of olivine and its polymorphs with various iron and water concentration at the pressure and temperature condition of MTZ without any extrapolation, which are ideal to constrain the water content of MTZ. Since water and iron have opposite effect on the density, the water content in MTZ is in a narrow range to match simultaneously the observed jumps of density and seismic wave velocities at the depth of 410 km. Such constrained water content in MTZ depends on the amount of olivine in the upper mantle.

[1] Núñez Valdez, M., Wu, Z., Yu, Y.G., Wentzcovitch, R.M., 2012b. Thermoelastic properties of ringwoodite $(Fe_x,Mg_{1-x})_2SiO_4$: its relationship to the 520km seismic discontinuity. Earth Planet. Sci. Lett.351–352, 115–122.

[2] Núñez Valdez, M., Wu, Z., Yu, Y., Wentzcovitch, R., 2013. Thermal elasticity of $(Fe_x,Mg_{1-x})_2SiO_4$: olivine and wadsleyite. Geophys. Res. Lett.40, 290–294.