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# Tracing water in the transition zone: from wadsleyite single-crystal elasticity to seismic observables

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Deep hydrogen cycling in Earth's mantle may affect global geodynamics by altering rock rheology, inducing melting, and enhancing diffusive material transport. The nominally anhydrous minerals wadsleyite and ringwoodite can incorporate hydroxyl groups in their crystal structures and thereby store large amounts of water in the transition zone. Hydration of these minerals affects their physical properties, which ultimately determine the seismic properties of transition zone rocks. Defining the seismic signature of a hydrous transition zone remains a key task for mineral physics as previous attempts to assess the hydration state of the transition zone have led to contradicting results. We performed simultaneous sound wave velocity and density measurements on iron-bearing wadsleyite single crystals with Fe/(Mg+Fe) = 0.11 at high pressures. Our results show that with increasing pressure both P-wave and S-wave velocities of our (nearly) anhydrous iron-bearing wadsleyite cross over with those of previously studied hydrous iron-bearing wadsleyite with identical Fe/(Mg+Fe) ratio. While different at ambient conditions, P-wave and S-wave velocities of anhydrous and hydrous iron-bearing wadsleyite become seismically indistinguishable at pressures of the shallow transition zone. We further verify available thermo-elastic parameters by first experiments on wadsleyite single crystals at combined high pressures and high temperatures and use these parameters to extrapolate our results to high temperatures. At realistic conditions of the transition zone, differences in sound wave velocities between anhydrous and hydrous wadsleyite potentially remain too small to be detected by seismic tomography. Instead, we combined our results on iron-bearing wadsleyite with reported elasticity data on wadsleyite and olivine as well as with recent results from our group on ringwoodite to model velocity, density, and acoustic impedance contrasts across the olivine-wadsleyite and wadsleyite-ringwoodite phase transitions. Assuming the 410-km discontinuity to arise from the olivine-wadsleyite phase transition, we show that the related impedance contrast and hence the reflectivity of the 410-km discontinuity are sensitive to hydration providing an indicator of hydration in the shallow transition zone. When linked to local seismic observations, our findings may contribute to detect reservoirs and pathways of deep hydrogen cycling.