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Elasticity of DHMS at mantle pressures: Implications for seismic velocities and anisotropy of subducted slabs

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Water transported and released into the upper mantle via subduction of oceanic lithosphere has a profound effect on the physical and mechanical properties of mantle materials and mediates tectonic processes such as volcanism at plate boundaries and deep seismicity. As seismology represents the preferred method to detect hydration, precise measurements of the sound velocities and elastic properties of candidate minerals are essential for the interpretation of the seismic velocity structure and the distribution of water storage sites in subducting slabs. Dense-hydrous magnesium silicates (DHMS) are recognized as important host for H_2O in the slab, but their elastic properties under subduction zone conditions are poorly constrained. Virtually no information exists on the shear properties of these important water carriers.

Here we address this problem by measuring the sound velocities and single-crystal elastic properties of Fe-bearing phase A (phA) and phase E (phE), two DHMS expected to play a major role in the transport of water in the upper mantle and transition zone. Measurements were performed by Brillouin scattering in samples compressed up to 16.5(2) GPa in the diamond-anvil cell using alcohol mixtures as pressure transmitting media. The results provide new insights into the behavior of hydrous minerals

under subduction zone conditions and the possibility of identifying hydration through seismic observations. In both cases, the shear properties of the materials are important factors in the conclusions reached. The results reveal that the compressional (Vp) and shear (Vs) aggregate velocities of phase A and phase E are significantly lower than those of other phases in slab peridotite with whom they coexist. The addition of 12% in volume of phase A or phase E to peridotite, however, has a minimal effect on the seismic velocities of the slab, suggesting that hydration would be difficult to detect based on seismic velocities alone. Combined observations obtained from the analysis of seismic parameters indicate that the presence of significant shear wave anisotropy (As), together with high Vp/Vs and Poisson's ratios, could be major diagnostic features for identifying the presence of these hydrous phases in cold subudcted slabs.