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Elasticity of stishovite and post-stishovite at high pressure: implications for understanding V_S anomalous seismic scatterers beneath subduction zones in the lower mantle

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Seismic wave scatterers with negative V_S anomalies have been widely found along subducting slabs in a depth range of 800-1600 km [1]. This observation has been previously linked to Al,H-dependent second-order phase transformation in stishovite in the mid-ocean ridge basalt (MORB) [2]. However, the high-pressure elastic property of stishovite and post-stishovite and compositional (Al and H) dependence of elasticity remain uncertain. Here, we synthesized three batches of stishovite crystals with different Al and H contents. We measured shear and compressional wave velocities (V_S and V_P) of Al-free and dry stishovite and post-stishovite using Brillouin and impulsive stimulated light spectroscopy, respectively, in a diamond-anvil cell (DAC) up to 70 GPa. These results were used to derive full elastic moduli (C_{ij}) of stishovite and post-stishovite phases at high pressure. Our results show that the C_{11} and C_{12} converge at transition pressure (~55 GPa) where the transverse wave propagating along [110] direction vanishes [3]. On the other hand, we also determined equation of state and optic mode frequencies of Al,H-bearing stishovite and post-stishovite at high pressure in a DAC using synchrotron X-ray diffraction and Raman spectroscopy, respectively. These data were used to derive full C_{ij}, V_S, and V_P within the framework of a pseudo-proper Landau theory [4]. The transition pressure where a major V_S reduction is observed is significantly reduced mainly due to Al and H substitutions. Furthermore, we modeled V_S and V_P profiles of MORB materials across the post-stishovite transition along cold-slab geotherms using Mie-Grüneisen equation of state. Modeled results are compared with representative velocity profiles along subducting slabs to evaluate V_S anomaly in MORB materials. These results are applied to understand seismological observations of depth-dependent V_S anomalies beneath subduction zone regions especially in Tonga.

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