Elasticity of Silica across the Post-stishovite Transition in the Lower Mantle

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The fate of subducted oceanic crust in the Earth's mantle has been considered to play a key role in understanding the geodynamic processes and chemical evolution of the Earth. Study of physical and chemical properties of subducted component of mid-ocean ridge basalt (MORB) is thus of great interest. Subducted MORB in the Earth's lower mantle contains up to 20 vol% of stishovite or post-stishovite $CaCl_2$-type phase [1]. The post-stishovite transition occurs at ~50 GPa and room temperature [2]. Because Landau theory and ab initio calculation have predicted a significant shear velocity (V_P) softening of stishovite across the phase transition [3, 4], the post-stishovite transition has been traditionally considered as a potential cause of reflectors/scatterers with low shear velocities observed in the lower mantle [5]. However, published experimental results of the elasticity of stishovite have been limited to conditions far lower than the transition pressure, because of either the pressure limitation using the ultrasonic interferometry or stithovite's V_P peak overlapping with diamond's compressional velocity (V_S) peak at high pressure using the Brillouin light scattering system (BLS). In order to interpret seismic observations, direct measurements of the elasticity of stishovite across the phase transition is essentially needed. In this study, we conducted V_S and V_P measurements on polycrystalline stishovite at relevant lower mantle conditions using both BLS and Impulsive Stimulated Light Scattering systems. Across the post-stishovite transition, we observed a V_P softening which is consistent with what theories predicted, whereas no V_S softening which is contrary to theoretical results. A modified Landau theory has been developed to fit the elastic softening within the post-stishovite transition. We will further discuss the effect of the phase transition on the elasticity and seismic parameters (adiabatic bulk modulus K_S, shear modulus μ, and Poisson's ratio ν) at lower mantle pressures. Our results imply that the elasticity of stishovite across the phase transition makes it invisible in the lower-mantle seismic profiles, and thus may not be responsible for reflectors/scatterers with low shear velocities in the Earth's lower mantle.

Reference:

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