Single-crystal elasticity of stishovite at high pressure: Implication for the seismic scatterers in the mid-lower mantle

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Mid-ocean ridge basalts (MORB) have been subducted into the Earth's lower mantle over the geological history. They have a distinct mineralogy from the surrounding mantle (either pyrolitic or perovskitic) [1]. For example, free silica (SiO_2) is a distinct phase and constitutes 20 vol% of MORB [1]. It attains a rutile-type structure which is called stishovite from top- to mid-lower mantle [2]. A ferroelastic transition from stishovite to a $CaCl_2$-type silica (the post-stishovite transition) occurs at the mid-lower mantle depth [2], and has been predicted to be accompanied by a significant softening of shear-wave velocity (V_S) (by as large as ~34 % compared to bare stishovite) [3]. Such abnormal elastic behavior has attracted seismologists' attention to explain some small-scale seismic heterogeneities in the lower mantle [4]. In the circum-Pacific region, scattering/reflecting of short-period seismic waves, seismic scatterers/reflectors, has been widely detected from the top- to mid-lower mantle [4]. They mainly exhibit low V_S anomalies ($dV_S \leq$ -4 % to > -10 %), and have been ascribed to compositional heterogeneities such as the presence of MORB in the region [4]. Ab-initio studies on the elasticity of MORB phases have suggested that MORB exhibits lower V_S than pyrolite by -2 % to -4 % in the mid-lower mantle depth due to the post-stishovite transition [5]. However, experimental studies on elasticity of stishovite across the transition are still lacking due to the technical limit. For example, in the single-crystal Brillouin light scattering (BLS) measurement, stishovite's V_P (compressional-wave velocity) is blocked by the diamond window at high pressure. Here, we investigated the single-crystal elasticity of stishovite using BLS (for V_S) and impulsive stimulated light spectroscopy (ISLS) (for V_P) up to transition pressure (~54 GPa) at room temperature. The derived elastic properties including elastic moduli and acoustic velocities were addressed using the Landau theory and a self-consistent model of thermodynamics and elasticity [3, 6]. These experimental results, together with elasticity of other MORB phases from literatures, were used to model the velocity profiles of MORB in the lower mantle which were further compared to those of the surrounding mantle. The velocity contrast between MORB and surrounding mantle will finally be applied to understand seismic scatterers in the mid-lower mantle.

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