The stishovite to post-stishovite phase boundary studied by stress cycling experiments in a dDAC

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Abstract

Stishovite and post-stishovite, the stable forms of SiO_2 at mantle conditions, are important mineral phases in the lower mantle, in particular in subduction zone environments, where Mid-Ocean Ridge Basalt (MORB), the crustal component of the subducting slabs, contains up to 20 Vol.% of SiO_2. Deeper, where MORB might delaminate from the rest of the subducting slab, it might stagnate at around 600-1000 km depth. Ultimately, MORB will sink toward the base of the mantle, potentially feeding the LLSVPs or other heterogeneities near the CMB. Other scenarii also propose that SiO_2 can exsolve into the mantle from the crystallising core, or that SiO_2-rich regions can exist as remnants of the magma ocean.

Stishovite and post-stishovite are thus important components of the dynamic mantle, in the regions that are the most crucial to image by seismology and advance our understanding of the dynamics of the Earth's interior.

The stishovite to post-stishovite transition is characterised by elastic anomalies, but its impact on mantle physical properties and seismic wave propagation has not yet been completely understood. For instance previous studies have reported softening of the shear modulus of stishovite near the phase boundary, with strong differences depending on the stress condition of the sample (isostress vs isostrain). Another study has highlighted a strong sensitivity of the phase transition to stress. Hence the real-world physical behaviour of polycrystalline SiO_2 across the stishovite to post-stishovite boundary under a cyclic loading, as imposed by a seismic wave in the mantle, could be different to what is expected based on hydrostatic equation of states or classic compression experiments. In addition, non-elastic responses to cyclic stresses, including attenuation, are poorly explored by experiments.

To directly investigate the response of stishovite and post-stishovite to a passing seismic wave, we performed cyclic loading experiments using the dynamic diamond anvil cell (dDAC). We used the dDAC setup available at the synchrotron beamline P02.2, at PETRA III, DESY, to simulate seismic waves in stishovite/post-stishovite samples, and followed the evolution of their unit cell and lattice strain using time-resolved X-ray diffraction.

Our preliminary results show that at pressure of about 50 GPa, volume strain response to stress in our samples arrives ~15 s later than lattice strain response, when the oscillation frequency is 0.01 s^{-1}. This lag of the volume strain response, however, decreases when increasing the cycling frequency from 0.01 to 0.1 s^{-1}. We will discuss the possible causes of this observation and, in particular, try to discriminate between an elastic or attenuation origin.