Single crystal elasticity of Fe-bearing phase E by Brillouin spectroscopy

*Niccolo Satta[1], Hauke Marquardt [2], Alexander Kurnosov[1], Tiziana Boffa Ballaran [1], Johannes Buchen[3], Catherine McCammon[1], Takaaki Kawazoe[4]

1. Bayerisches Geoinstitut, University of Bayreuth, 95440 Bayreuth, Germany, 2. Department of Earth Sciences, University of Oxford, South Parks Road, Oxford, UK., 3. Seismological Laboratory, California Institute of Technology, Pasadena, CA 91125, USA., 4. Department of Earth and Planetary Systems Science, Hiroshima University, Hiroshima 739-8526, Japan.

Earth’s deep water cycle plays a key role for the dynamic evolution of our planet and the development of habitable conditions. Surface water can be transported to Earth’s mantle by subduction of oceanic lithosphere. Experimental investigations have shown that water can be efficiently stored in Dense Hydrous Magnesium Silicates (DHMS) in cold subducting slabs. However, quantification of the incoming water budget based on the interpretation of seismological observations is hampered by a lack of elasticity measurements of DHMSs. Here, we report single-crystal elasticity measurements of Fe-bearing phase E, a DHMS that is stable at pressures and temperature of Earth’s mantle transition zone. A very low bulk modulus has been reported for phase E, suggesting that it might produce seismic velocity heterogeneities detectable by seismological investigations. However, the shear modulus of phase E has not been quantified.

We synthesized Fe-bearing phase E single crystals in a multi-anvil apparatus. Chemical composition as well as crystal structure have been determined using electron microprobe analysis, Mössbauer spectroscopy, and single-crystal X-ray diffraction. We derived the full elastic stiffness tensor by Brillouin spectroscopy on two single crystals of selected orientations. We found phase E to have both the lowest bulk modulus and shear modulus among the DHMSs at ambient conditions. Phase E shows very low compressional and shear velocities especially when compared to the other principal minerals likely present in subducting slabs after serpentine breakdown. Modelling of seismic velocities in dry and hydrated upper mantle and transition zone rocks suggests that the presence of even small amounts of phase E can appreciably lower seismic wave velocities. Phase E could be used as seismological indicator for water stored at depth in subducting scenarios. The elasticity of phase E under mantle conditions will be explored in future research.

Keywords: Brillouin scattering, Phase E, Seismic wave velocities

