Equation of state of fluids from sound velocity measurements in the diamond anvil cell using Brillouin scattering spectroscopy

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Saline-rich aqueous fluids play an important role in metamorphic reactions and chemical transport in a wide range of geological environments. In subduction zones, aqueous fluids expelled from subducting slabs lead to the important geochemical phenomena of mantle wedge metasomatism and arc magmatism and mediate the recycling of elements in the Earth. Reconizing the role of deep fluid in these processes a number of significant but unanswered questions arise as to their chemical composition, the extent of mass transfer, or the mechanism of elemental transport from the slab to the mantle wedge. Answers to these questions depend on quantitative thermodynamic modelling of fluid-mineral interactions, that is greatly limited by the lack of thermodynamic data of complex aqueous fluids at high pressure and temperature conditions [1].

To address this problem, we conducted sound velocity measurements in the diamond anvil cell using Brillouin scattering spectroscopy to determine the equation of state (EoS) of H_2O and chlorine-bearing solutions (1m and 3m NaCl) up to 400 ºC and 7 GPa. Sound velocities measured in H_2O are in excellent agreement with previous measurements using the Impulsive Stimulated Brillouin Scattering technique [2]. The newly determined equation of state is used to evaluate the pressure and temperature dependences of thermodynamic properties of water and NaCl solutions, including thermal expansion coefficients, isothermal and adiabatic compressibilities and heat capacities. The results are combined with previous experimental and theoretical EoS of H_2O-NaCl mixtures to provide an internally consistent dataset for the thermodynamical properties of the most relevant aqueous systems involved in subduction process.

References

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Effect of Al^{3+} on the elastic properties of ferropericlase at high pressure

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Main features of the Earth's mantle structure revealed by seismic observations, including the radial profile, lateral heterogeneity, and anisotropy are largely determined by the elasticity of the materials present in this region [1]. Minealogical models indicate that the lower mantle consists of approximately 20% ferropericlase (Mg,Fe)O and more than 70% of silicate perovskite [(Mg,Fe)SiO_3], containing minor amounts of aluminium. Although the effect of Al^{3+} incorporation on the elastic properties of $MgSiO_3$ perovskite has been constrained from several studies [2,3], nothing is known about how this element can affect the sound velocities and elasticity of (Mg,Fe)O.

In this contribution we present high-pressure measurements on the sound velocities and single-crystal elastic properties of aluminium-bearing ferropericlase (containing 2.4 atom% Al^{3+} and 8.7 atom% Fe^{2+}) to 25 GPa at room temperature. Measurements were performed by Brillouin scattering in samples compressed in the diamond-anvil cell using alcohol-water mixtures as pressure transmitting media. The pressure-dependence of the aggregate compressional (V_P) and shear (V_S) wave velocities, as well as, the adiabatic bulk (K_S), shear (μ) moduli and elastic anisotropy were obtained. In view of these results and previous elastic data for (Mg,Fe)O [4], the effect of Al^{3+} incorporation on the elastic properties ferropericlase and the implications for the chemical composition of the Earth's lower mantle will be discussed.

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