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Fe3S の状態方程式と音速に基づいた内核中の硫黄量
Amount of sulfur in the inner core based on sound velocities and EOS of Fe3S at high pressures

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The structure and seismic properties of the Earth's inner core have not been understood well. The observation of shear wave velocities in the inner core raised an issue because the observed shear wave velocities were unexpectedly low (Cao et al., 2005). Due to lack of the knowledge about elastic properties of the core materials, it is difficult to interpret the observed seismic wave velocities.

There have been only a limited number of works for V_P of Fe and Fe alloys with light elements, especially Fe alloys with sulfur. Recently, sound velocities of Fe, Fe-Ni, FeS, FeS_2, FeO, Fe_3C, Fe-Ni-Si alloys have reported based on an inelastic X-ray scattering (IXS) (Fiquet et al., 2001; Antonangeli et al., 2004; Fiquet et al., 2004; Badro et al., 2007; Fiquet et al., 2009; Antonangeli et al., 2010). In the Fe-S system, V_P of FeS, the end member of the Fe-FeS system, and FeS_2, more sulfur-rich compound, have been studied but these compounds are not appropriate for the inner core materials because Fe-S system has a lot of intermediates such as Fe_3S_2, Fe_2S, Fe_3S under high pressures (Fei et al., 1997, 2000). In addition, under the core conditions, only Fe_3S coexists with hcp-Fe as a subsolidus phase (Kamada et al., 2010, 2012). Therefore, it is essential to study the V_P of Fe_3S to understand seismic and chemical properties of the Earth's core. The EOS of Fe_3S is also important to estimate the density deficit of the inner core.

In this study, a synthesized Fe_3S or a foil made from Fe and FeS powder mixture was used as a starting material. A symmetric diamond anvil cell was used to generate high pressures. IXS experiments were performed at the beamline 35XU of SPring-8, Japan (Baron et al., 2000) and X-ray diffraction experiments were performed at the beamline 10XU of SPring-8. V_P of Fe_3S were measured up to 85 GPa and the EOS of Fe_3S were determined to 200 GPa. The present results suggest that VP of Fe_3S follow the Birch's law. According to sound velocity measurements, it is needed to take account of temperature dependence on V_P to explain the inner core V_P. The amount of sulfur in the inner core was estimated to be 13.5 at% based on 4th order Birch-Murnaghan EOS. This amount of sulfur is much larger than the previous estimation (e.g., Chen et al., 2007). Therefore, there might be some other light elements in the core, such as O and/or Si.

Keywords: Fe3S, Inner core, sound velocity, equation of state