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Sound velocity of iron-light-element alloys at high pressure and temperature and composition and thermal state of the in

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Sound velocity is the most accurate observable properties of the earth's interior and can provide important clues on structure and composition of the core. In spite of their importance, the sound velocity data of the core materials at high pressure are still very limited due to technical difficulties.

We measured the compressional velocity of hcp-iron and other iron-light element alloys by the inelastic X-ray scattering (IXS) method using DAC at high pressure and temperature. We measured the velocity up to 174 GPa at room temperature to 91 GPa at temperatures to 1000 K using the external heating diamond anvil cell. We also measured the compressional velocity and density of Fe0.83Ni0.09Si0.08 alloy to 151 GPa and Fe3S up to 85 GPa at room temperature. Inelastic X-ray scattering spectra were taken at BL35XU, Spring-8.

The present compressional velocity-density relation of hcp-Fe at 300 K is consistent with recent IXS results obtained by Mao et al. [2012] and Antonangeli et al. [2012]. This work shows almost no temperature effect, i.e., Birch's law is applicable up to the temperature of at least 1000 K at c.a. 91 GPa. We obtained the following Birch's law by fitting our results and the recent hcp-Fe data-sets at 300 K: Vp [km/s] = 1.174(+-0.031)d[g/cm3] ? 3.591(+-0.326). The compressional velocity and density curves for hcp-Fe0.83Ni0.09Si0.08 alloy, Fe3S and hcp-Fe of Birch's law locate above those of the PREM inner core in the velocity-density diagram. Thus these observations indicate following two possibilities, i.e., hcp-Fe has a large temperature effect on Birch's law as was suggested by some theoretical works [Vocadlo et al., 2009; Sha and Cohen, 2010] or the inner core contains some amounts of heavy elements such as Ni with a negligible temperature effect on Birch's law. In the latter case we need higher temperature of the inner core in order to reduce the density of iron-nickel alloy to match the PREM inner core density. The amount of light and heavy elements of the inner core for a given inner core temperature, i.e., a plausible composition-temperature model of the inner core will be presented.

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