Sound velocities and density measurements of solid hcp-Fe and hcp-Fe-Si(9wt.%) alloy at high pressure: Constraints on the Si abundance in the Earth's inner core

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Abstract

The presence of light elements alloyed to iron in the Earth's core is well established, and core formation models based on metal-silicate equilibration point at silicon as one of the major light element in the inner core. However, attempts to constrain Si abundance on the basis of comparison of measured velocities in pure Fe and Fe-Si alloys at high pressure with seismic observations do not provide a unique answer. Available data obtained in the 40-100 GPa range are indeed limited in number and in open disagreement. We carried out sound velocity and density measurements on pure hcp-Fe and an hcp-Fe-alloy with 9 wt.% Si at 300 K up to _˜170 and _˜ 140 GPa, respectively, by inelastic x-ray scattering and x-ray diffraction. The results, combined with previous experiments and calculations, allow a precise determination of the Vp-ρ and Vs-ρ relations for pure Fe and the Fe-Si alloy. The established relations are used to address the effect of Si on the velocities in the Fe-FeSi system in the range of Si concentrations 0 to 9wt.% applicable the Earth's core. Assuming an ideal linear mixing model, velocities vary with respect to those of pure Fe by _˜ +80 m/s for Vp and _˜ -80 m/s for Vs for each wt.% of Si at the inner core density of 13000 kg/m3. The possible presence of Si in the inner core and the quantification of its amount strongly depend on anharmonic effects at high temperature and on actual core temperature.

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