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Limited silicon content in the solid inner core

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Silicon (Si) incorportation into the Earth's core is considered as one of the consequences during core-mantle differentiation, particularly in a relative rediced accretion environment and deep magma ocean. Density measurements of Fe-Si solid and liquid under core conditions by static and dynamic compression method show that about 9 and 4 wt.% Si are required to account for the density deficits in the liquid outer core and the solid inner core, respectively. Limited Si partitioning experiments simulating liquid outer core and solid inner core indicate that Si-bearing iron alloy would be the first solid crystalized from liquid during cooling. New sound velocity measurements in this study address the question if 4 wt.% Si would also satisfy the observed compressional and shear wave velocities in the solid inner core. We conducted shockwave experiments to determine the compressional and shear wave velocities of Fe and Fe-8.6wt%Si up to 230 GPa and 5400 K. The shear wave velocity is directly derived from measurements of both the compressional and bulk sound velocities. Comparison of our simultaneous high P-T Hugoniot data with presious static data at room temperature shows that the measured compressional wave velocities for pure Fe and Fe-8.6wt%Si follow Birch's law. We also evaluate the effect of temperature and composition on the shear wave velocity and conclude that neither the effect of temperature nor incorporation of Si can explain the observed low shear wave velocity in the inner core. Any proposed composition models of the inner core must simultaneously satisfy the core density, the compres- sional wave velocity, and shear wave velocity of the solid inner core, defined by seismic observation. The sound velocity measurements strongly suggest limited Si content in the solid inner core. The solution to the problem requires additional light element(s) that can further reduce the shear wave velocity.