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A New Experiment-Based Density-Velocity-Compositional Model of the Earth's Inner Core

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Understanding the composition of the Earth's core is integral to answering many questions in the Earth Sciences, including the conditions, mechanisms, and timing of core formation, as well as the interactions between the core and the mantle, which also has important implications for the composition of the Earth's mantle. Because of the remote nature of the core, seismic profiles of the Earth's interior must be relied upon to determine the velocity and density structure of the deep Earth, and these profiles must then be compared with experimental data on candidate core phases at extreme conditions. The work presented here will show the results of ultrasonic interferometry measurements at high pressures and temperatures extrapolated to pressures and temperatures relevant to the Earth's inner core for direct comparison with seismic profiles.

A density-velocity-compositional model was constructed for the solid inner core by accommodating for the recent evidence from these ultrasonic experiments that iron minerals may not follow a linear "Birch's Law" density-velocity relationship. By accounting for this non-linearity, the first model that is in good agreement with all aspects of the Preliminary Reference Earth Model (PREM) in the inner core, including shear velocities, has been generated. In addition, this model was then compared to existing cosmochemical and experimental data, as well as element partitioning studies, to form a more comprehensive model of the Earth's inner and outer cores. The results of this model are also in excellent agreement with geochemical constraints on light-element content of the core, and can begin to reconcile the density deficits observed in the liquid outer core. This is the first model to have good agreement with all the parameters of PREM in the inner core, including density, VP, bulk sound speed, VS, KS, and G, and it also resolves most of the density deficit in the liquid outer core.

Keywords: Ultrasonic Interferometry, Acoustic Velocities, High Pressure and Temperature, Experimental, Elasticity, Inner Core