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SPECIAL COLLECTION: BUILDING PLANETS: THE DYNAMICS AND GEOCHEMISTRY OF CORE FORMATION

The axial ratio of hcp Fe and Fe–Ni–Si alloys to the conditions of Earth's inner core†

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ABSTRACT

The Earth's iron-rich inner core is seismically anisotropic, which may be due to the preferred orientation of Fe-rich hexagonal close packed (hcp) alloy crystals. Elastic anisotropy in a hexagonal crystal is related to its *c*/*a* axial ratio; therefore, it is important to know how this ratio depends on volume (or pressure), temperature, and composition. Experimental data on the axial ratio of iron and alloys in the Fe–Ni–Si system from 15 previous studies are combined here to parameterize the effects of these variables. The axial ratio increases with increasing volume, temperature, silicon content, and nickel content. When an hcp phase coexists with another structure, sample recovery and chemical analysis from each pressure-temperature point is one method for determining the phase's composition and thus the position of the phase boundary. An alternate method is demonstrated here, using this parameterization to calculate the composition of an hcp phase whose volume, temperature, and axial ratio are measured. The hcp to hcp+B2 phase boundary in the Fe–FeSi system is parameterized as a function of pressure, temperature, and composition, showing that a silicon-rich inner core may be an hcp+B2 mixture. These findings could help explain observations of a layered seismic anisotropy structure in the Earth's inner core.

Keywords: Elastic anisotropy, Fe alloys, high pressure, diamond-anvil cell, X-ray diffraction, phase diagrams, phase transition, inner core