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Viscous strength of hcp iron at conditions of Earth's inner core

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The Earth's inner core is primarily composed of solid iron and is exposed to pressures of ~330-360 GPa and to temperatures corresponding to that of the surface of the sun. Its transport and rheological properties determine the rotational dynamics and deformation of the inner core. However, the rheology of the inner core is poorly understood. In a recently published paper in *Scientific Reports* ([1]Ritterbex & Tsuchiya 2020), we propose a theoretical mineral physics approach based on the density functional theory to constrain the viscosity of hexagonal close packed (hpc) iron, the most likely phase of iron stable in the inner core. Since plastic deformation is rate-limited by atomic diffusion at the extreme pressure and temperature conditions of Earth's center, we quantify self-diffusion in hcp iron non-empirically. Results are used to model the rate-limiting creep behavior of hcp iron, suggesting dislocation creep to be a potential mechanism driving inner core deformation which might contribute to the observed seismic anisotropy of the inner core. The associated viscosity agrees well with geodetic estimates supporting that the inner core is significantly less viscous than Earth's mantle. We demonstrate that the predicted low viscosity of hcp iron is consistent with a strong gravitational coupling between the inner core and mantle compatible with seismic observations of small fluctuations in the inner core rotation rate. We will discuss why the inner core is too weak to undergo translational motion, one of the hypotheses to explain the hemispherical patterns of seismic anisotropy in the inner core. Instead, our results provide evidence that mechanical stresses of tens of pascals are sufficient to deform hcp iron by dislocation creep at extremely low geological strain rates, comparable to the candidate forces able to drive inner core convection.

[1]S. Ritterbex and T. Tsuchiya (2020). Viscosity of hcp iron at Earth's inner core conditions from density functional theory. Scientific Reports **10**, 6311. [doi:10.1038/s41598-020-63166-6]