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Viscosity of Earth's inner core constrained by Fe–Ni interdiffusion in Fe–Si alloy in an internal-resistive-heated diamond anvil cell

Yohan Park[1], Kyoko Yonemitsu[2], Kei Hirose[2,3], Yasuhiro Kuwayama[2], Shintaro Azuma[1], and Kenji Ohta[1,*]

[1]Department of Earth and Planetary Sciences, Tokyo Institute of Technology, Tokyo 152-8551, Japan
[2]Department of Earth and Planetary Science, The University of Tokyo, Tokyo 113-0033, Japan
[3]Earth-Life Science Institute, Tokyo Institute of Technology, Tokyo 152-8550, Japan

Abstract

Diffusivity in iron (Fe) alloys at high pressures and temperatures imposes constraints on the transport properties of the inner core, such as viscosity. Because silicon (Si) is among the most likely candidates for light elements in the inner core, the presence of Si must be considered when studying diffusivity in the Earth's inner core. In this study, we conducted diffusion experiments under pressures up to about 50 GPa using an internal-resistive-heated diamond-anvil cell (DAC) that ensures stable and homogeneous heating compared with a conventional laser-heated DAC and thus allows us to conduct more reliable diffusion experiments under high pressure. We determined the coefficients of Fe–nickel (Ni) interdiffusion in the Fe–Si 2 wt% alloy. The obtained diffusion coefficients follow a homologous temperature relationship derived from previous studies without considering Si. This indicates that the effect of Si on Fe–Ni interdiffusion is not significant. The upper limit of the viscosity of the inner core inferred from our results is low, indicating that the Lorentz force is a plausible mechanism to deform the inner core.

Keywords: Earth's inner core, diffusion, viscosity, iron, silicon, high pressure