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Low thermal conductivity of Earth's core with implications for the geodynamo and the age of inner core

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Thermal conductivity of Earth materials under relevant high pressure-temperature conditions is crucial to determine the temperature profile in Earth's interior, which further influences its thermo-chemical evolution and structures as well as geodynamics. In Earth's core, iron (Fe) is the major constituent along with some candidate light elements, for instance, silicon (Si), carbon (C), sulfur (S), etc. Core's thermal conductivity plays a key role in affecting its thermal evolution history and the magnitude of thermal and compositional sources required to operate a geodynamo. Precise and direct measurements of the thermal conductivity of Earth's core materials under extreme conditions, however, have been very challenging due to the difficulty of experimental methods. Recently we have combined time-resolved optical techniques with high-pressure diamond cells to precisely measure the thermal conductivity of core materials, including pure Fe and Fe-Si and Fe-C alloys, etc. We found that the alloying effect by these candidate light elements results in a relatively low thermal conductivity compared to the pure Fe. Combined with thermal evolution models, our new data suggest a low minimum heat flow across the core-mantle boundary than previously expected, and therefore less thermal energy needed to run the geodynamo. In addition, the age of the inner core is constrained to be older than about two billion years.