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RECENT STUDIES AT THE EARTH-LIFE SCIENCE INSTITUTE (ELSI), TOKYO TECH

One of the scientific goals of the Earth-Life Science Institute (ELSI), which is at the Tokyo Institute of Technology (Japan), is to better understand the origin of the Earth—a very interdisciplinary topic. Recent ELSI research includes finding that the thermal conductivity of Earth's core is three times as high as previously estimated. We at ELSI measured the electrical resistivity of iron and alloys (Fig. 1) from which thermal conductivity was calculated based on the Wiedemann–Franz law (Gomi et al. 2013; Ohta et al. 2016). The data were collected from experiments conducted in a laser-heated diamond-anvil cell (DAC) up to a pressure of 157 GPa and a temperature of 4,490 K. The effect of temperature on the electrical resistivity of metal is usually described by the Bloch–Grüneisen law, which predicts a linear temperature dependence and, therefore, very high resistivity at core temperatures. However, our experimental data show that the resistivity is lower than such predictions, possibly because of the effect of resistivity "saturation": this is an effect whereby the mean free path between electron scattering events should be larger than the interatomic distance. This effect is widely known in metallurgy but has not, to our knowledge, been addressed in the geophysics literature.

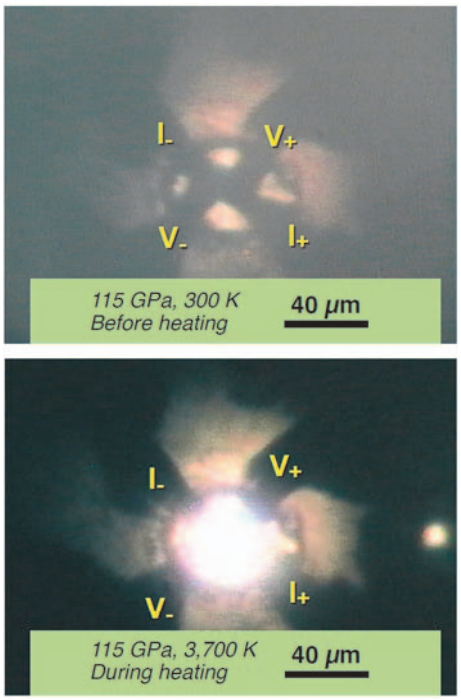

Figure 1 Electrical resistivity measurement at high pressure and temperature. Image from Ohta et al. (2016).

Low electrical resistivity means high thermal conductivity, which has profound implications for the thermal history of the core and the origin of Earth's geodynamo. Recent paleomagnetic field intensity measurements by Tarduno et al. (2015) indicate that the geodynamo has been functional since the early history of the Earth, possibly from the Hadean Era. Scientists have assumed that thermal convection was responsible for the geodynamo, at least before the onset of inner core crystallization. If this were the case, however, the thermal evolution model for the core, as reported by Labrosse (2015) and using our high conductivity value, suggests that the temperature at the top of the core should have exceeded 6,000 K during the Hadean. This problem is called the "new core paradox" (Olson 2013). More than one alternative mechanism has already been already proposed, which will be a matter of debate in the near future (see http://www.nature.com/news/magnetic-mystery-of-earth-s-early-core-explained-1.19058).

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