Core-mantle interaction through liquid magnesium silicate release from the Earth's core

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Experimental studies over the past few years[1,2] showed that liquid iron has a high thermal conductivity, making it difficult to drive the geodynamo by cooling the Earth's core for long through its geological history, despite paleomagnetic evidence for a long-term dynamo[3]. Alternatively, running a compositionally-driven dynamo seems possible based on the solubility of either Mg[4] or Si+O[5] in liquid iron, crystallizing MgO or SiO_2. We report here on joint solubility experiments of Mg+Si+O in iron and show that the first crystallizing phase from core metal saturated in Mg+Si+O in a magma ocean, transported to the core, and subsequently cooled there is SiO_2 followed by liquid magnesium silicate. Energetically, this is an efficient way to drive a long-term dynamo: only 50-150 K of core cooling is required for magnetic field production over 4 Gyr[5]. The material released from the core can also potentially react with mantle silicate, producing seismic phenomena such as ultra-low velocity zones and low shear velocity regions[6] at or near the core-mantle boundary (CMB) in a way distinctly different than core-mantle reaction at the CMB. In particular, we examine how siderophile elements could be carried into the mantle by this process, involving metal-silicate exchange within the core itself. Isotopic fractionation of Mn[7] would be affected at an analytically detectable level and transfer of W and Pt may complicate inferences of core formation and inner core nucleation.

[1] Gomi *et al*. (2013) *PEPI* **224**, 88-103. [2] Ohta *et al*. (2016) *Nature* **534**, 95-98. [3] Tarduno *et al*. (2015) *Science* **349**, 521-524. [4] Badro *et al*. (2016) *Nature* **536**, 326-328. [5] Hirose *et al*. (2017) *Nature* **543**, 99-102. [6] Garnero & McNamara (2008) *Science* **320**, 626-628. [7] Willbold & Elliott (2017) *Chem. Geol* **449**, 253-268.