Evolution and structure of an outer core crystallizing SiO_2

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Recent results in the Fe-O-Si system from diamond-anvil cell experiments at Earth's core pressures and temperatures [1] show that SiO_2 is the liquidus phase in a wide compositional range. The thermodynamic model for SiO_2 saturation derived from the experiments permits the core's compositional evolution to be modeled from the time of core formation to the present. Conditions in a magma ocean between 30-50 GPa [2-4] allow for significant incorporation of Si + O in the metal, which, while the core evolves to its present temperature (3500-4500 K at the CMB), leads to exsolution of SiO_2. The high efficiency of driving a dynamo by crystallization allows a dynamo of comparable strength to the present to be powered throughout Earth history, regardless of the possibility of a high thermal conductivity in the core. Using a transition-element hard-sphere model for seismic wavespeeds [5], we show by matching the wavespeed depression at the top of the outer core [6] that slow, continuous crystallization of SiO_2 at the top of the core produces denser, iron-enriched liquid that mixes downward. The net effects lead to reduced wavespeeds in the top of the outer core that correspond to a change in concentration of the SiO_2 component in the liquid of about 0.45 wt% in the top ~300 km of the core.

[1] Hirose *et al*. (2017) *Nature* **543** pp. 99-102. [2] Siebert *et al*. (2012) *Science* **339** pp. 1194-1197. [3] Rubie *et al*. (2011) *EPSL* **301** pp. 31-42. [4] Wood *et al*. (2006) *Nature* **441** pp. 825-833. [5] Helffrich (2015) *EPS* **67** pp. 73-84. [6] Helffrich and Kaneshima (2010) *Natue* **468** pp. 807-810.