Crystallization of SiO_2 from the outer core: A possible means of stratification

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The PREM seismic wavespeed model in the outermost core is in near-uniform self-compression. Slight deviations from self-compression constitute evidence for a radial compositional gradient there, and possibly for stable stratification. Based on melting experiments in the Fe-Si-O system in the diamond anvil at outer core pressures and temperatures that show crystallization of SiO_2, we developed a thermodynamic model of SiO_2 saturation in liquid Fe at high pressure and temperature conditions suitable for modeling magma ocean and outer core processes. Conditions in a magma ocean between 30-50 GPa allow for significant incorporation of Si + O in the metal, which, after the core evolves to its present temperature (3500-4500 K at the CMB), leads to exsolution of SiO_2. Using a transition-element hard-sphere model for seismic wavespeeds, we show that the continuous crystallization of SiO_2 at the top of the core produces denser, iron-enriched liquid that mixes downward into the core. The net effects of the density and mean atomic weight change in the mixed region leads to reduced wavespeeds in the top of the outer core that require only a small change in concentration of the SiO_2 component in the liquid, about 0.15 wt%.

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