Crystallization of SiO_2 in the core before inner core formation

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Core formation models based on partitioning of moderately siderophile (iron-loving) elements suggests that core metals segregated from silicates at high pressure (~40–60 GPa) and high temperature (*P-T*) (>3,000 K) in a deep magma ocean. The partitioning of silicon and oxygen in liquid iron are strongly enhanced at such high *P-T*, such that the core was originally rich in both silicon and oxygen. We performed crystallization experiments on liquid Fe–Si–O alloys to core pressures in a laser-heated diamond-anvil cell (DAC), using fine-grained homogeneous starting materials with different Si/O ratios. Our data demonstrate that the liquidus field of SiO_2 is very wide at the Fe-rich portion of the Fe–Si–O ternary system, indicating that the original Fe–Si–O core crystallized SiO_2 oxide until it lost either silicon or oxygen (or both). Such SiO_2 crystallization continued until the onset of inner core formation. The present-day liquid outer core does not include both silicon and oxygen, because otherwise a metallic inner core cannot be formed. The recent finding of high thermal conductivity of the core suggests that core thermal convection is difficult to sustain without extreme degrees of secular cooling. However, even for modest degrees of joint Si-O incorporation into the early core, the buoyancy released by crystallization of SiO_2 is sufficient to overcome thermal stratification and sustain the geodynamo. This may be a more likely mechanism than the precipitation of magnesium from the core proposed by O'rourke & Stevenson (2016), which requires very high-temperature core formation (>5,000 K).