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Investigating magma ocean solidification on Earth through laser-heated diamond anvil cell experiments

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We carried out a series of silicate fractional crystallisation experiments at lower mantle pressures using the laser-heated diamond anvil cell. Phase relations and the compositional evolution of the cotectic melt and equilibrium solids along the liquid line of descent were determined and used to construct the melting phase diagram. In a pyrolitic magma ocean, the first mineral to crystallise in the deep mantle is iron-depleted calcium-bearing bridgmanite. From the phase diagram, we estimate that the initial 33–36% of the magma ocean will crystallise to buoyant bridgmanite. Substantial calcium solubility in bridgmanite is observed up to 129 GPa, and significantly delays the crystallisation of the davemaoite during magma ocean solidification. Residual melts are strongly iron-enriched as crystallisation proceeds, making them denser than any of the coexisting solids at deep mantle conditions, thus supporting the terrestrial basal magma ocean hypothesis.