Silicon and oxygen partitioning between silicate and iron at core formation conditions

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The Earth's core is thought to have formed by the segregation of Fe-rich metallic liquid from one or more silicate magma oceans early in Earth's history. The core's density deficit requires that some fraction of its mass is accounted for by light elements, with Si and O being two strong candidates [1]. It is unlikely that the core has completely re-equilibrated with the solid mantle, and thus, the Si and O budgets of the core are largely dictated by their partitioning behaviour during early metal-silicate equilibration. Previous metal-silicate partitioning experiments are contradictory in terms of the pressure and temperature dependence of partitioning, which in part reflects the extrapolation to core formation conditions of experiments that are often performed at much lower pressure. The partitioning behaviour of Si and O is also complicated by interactions with other species present, particularly in the metal phase, making it difficult to assess the applicability of experimental-derived K_D values from different chemical systems to core formation conditions. We performed laser-heated diamond anvil cell (DAC) experiments at a range of pressures (25-66 GPa) and superliquidus temperatures in order to examine the partitioning behaviour of silicon and oxygen between immiscible silicate and metal liquids in the simple Fe-Mg-Si-O system. Mg has been suggested to be important for sustaining early Earth's geodynamo [2], and its partitioning behaviour is also investigated. We have attempted to achieve a lower oxygen fugacity than previous DAC experiments [3,4] by using a Si-Fe foil starting material placed within pure forsterite. Experimental products are analysed by transmission electron microscopy and electron microprobe after focused ion beam sample preparation. The results are interpreted within a thermodynamic framework in order to interpolate or extrapolate to core formation conditions to model the pressure and temperature conditions of core segregation from the early Earth's magma ocean(s) and the possible light element composition of the core at the time of its formation.

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