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Percolation threshold of iron-sulfide melts in olivine matrix: An experimental study with a centrifuging piston cylinder

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There are several theories about metal-silicate segregation and the formation of the Earth's core. One of them is the percolation of iron-sulfide melts through a solid silicate matrix, but the efficiency of such a mechanism is still under discussion. The main goal of the present investigation is to determine the percolation threshold for a simplified composition of the Earth core and silicate mantle and to verify whether buoyancy driven segregation of such metal-rich (anion-poor) melts is feasible. Starting materials are mixtures of natural olivine (S. Carlos) and iron-sulfide powder with the eutectic composition of the Fe–FeS system. The experimental apparati used are a standard end-loaded piston cylinder and a newly developed centrifuging piston cylinder. This rotating piston cylinder spins to a maximum speed of 2900 rpm (equivalent to an acceleration of 3000 g) at experimental conditions to 1.5 GPa and 1300 °C (standard 14 mm diameter, salt–pyrex assembly).

In static experiments, from BSE images of quenched samples, we observe interconnection of the melt at 20 vol%, whereas at 10 vol% the melt is mainly located in isolated pockets and triple junctions. We performed centrifuge experiments with mixtures containing 20 vol% of melt in an olivine matrix and an additional thin layer of pure Fe–FeS melt on top of the olivine-melt. No sign of a melt displacement towards the bottom of the capsule is observed (the molten iron–sulfide remains homogeneously distributed in the olivine matrix), although theory predicts melt segregation velocities of 40 mm/h at 100 g. A reason for this behavior could be a high surface tension of the metallic melt that hinders its mobility in the inter-grain space. Centrifuge experiments with olivine plus silicate melt have shown that melt segregates towards the top of the capsule, proving that the experimental set-up is proper to study percolation in partially molten systems. Thus, the absence of segregation for the iron-sulfide

melt cannot be ascribed to the experimental procedure.

In conclusions, the percolation of a metallic-rich melt through solid silicates does not seem a plausible mechanism for core formation in terrestrial planets (at least in absence of shear deformation) at reducing conditions.

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