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Conditions of core melt segregation in planetesimals

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Small bodies, such as planetesimals and protoplanets, are considered to be direct building blocks of the terrestrial planets, interior structures of these small bodies are closely linked to the core formation process in planet interiors. The core-mantle differentiation in small bodies has been reported to occur within first million years after the formation of the solar system (Kruijer et al. 2014). Wetting property of iron-alloy melts in silicate mantle minerals, olivine and orthopyroxene (opx), controls core formation process in these small bodies. Wetting property between Fe–S melt and olivine has been studied in previous studies (e.g., Minarik et al. 1996, Gaetani and Grove 1999, Terasaki et al. 2005, 2008). Although opx is reported to be more abundant in some primitive achondrite (Zeng et al. 2019), wetting behavior between iron-alloy melt and opx has not been studied.

In this study, we evaluate conditions of segregation between Fe–S melt and opx at the conditions of small body interiors based on textural characteristics of recovered samples. High pressure and high temperature experiments were carried out at 0.5–2.5 GPa and 1474–1523 K for 12 h duration using the piston cylinder and multi-anvil apparatus. We used powder mixtures of Fe–S and synthetic opx (Fe#=0.23-0.30) as starting material. The dihedral angle between Fe-S and opx was measured from back-scattered electron image of the recovered samples. Measured dihedral angle between Fe–S melt and opx ranges 54–102^{o}. Interconnected networks of Fe–S melt were observed in opx grain boundaries up to around 1.5 GPa, whereas Fe–S melt was isolated above these pressures. This behavior is closely related to the variation of melt composition with pressure. Combining the present results with the results of previous studies, we constrain the conditions of occurrence of percolative core formation in small bodies.