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The effect of Si on dihedral angles between metallic Fe-rich liquids and forsterite and magnesium silicate perovskite

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During terrestrial planet core formation the efficient separation of an Fe-rich liquid from a solid silicate mantle assemblage requires porous flow to occur. The most important factor in this context is the dihedral angle between crystalline silicates and liquid metal. Previous studies have shown that the solubility of S and especially O in Fe-rich melts have a strong effect in reducing dihedral angles such that the wetting boundary of 60˚ could be approached in relatively oxidised planetary bodies. Besides S and O, Si is also frequently proposed as an element that may have alloyed with Fe during core formation. Models supporting the presence of Si in the core often propose an initial relatively reducing stage of core formation followed by subsequent more oxidising conditions. If Si were found to promote porous flow of liquid Fe metal though silicate assemblages this would lend significant support to such models.

In order to examine whether Si has an influence on the wetting characteristic of a core forming metal melt in a silicate matrix a series of high-pressure experiments between 5 and 25 GPa and 1600-2000˚C have been performed. As starting materials $Fe_{91}Si_9$ and $Fe_{83}Si_{17}$ alloys were used in combination with synthetic forsterite at 5 GPa; at 25 GPa synthetic enstatite was used as a starting material for silicate perovskite. Up to 1750˚C the duration of the experiments was between 17 and 72 hours and between 6 to 7 hours at temperatures above 1830˚C. Graphite capsules were employed in order to ensure reducing conditions. Only at the highest temperatures was Si metal observed to oxidize whereas in attempts using MgO capsules this was a common effect. Redox conditions were low such that in initial experiments where Fe-bearing silicates were employed tiny metallic Fe droplets formed that pined grain boundaries and inhibited textural

equilibration. All experiments were carried out using a multi-anvil apparatus and octahedral assemblies of 18 and 10mm edge length. Imaging and semiquantitative analyses were performed with SEM and EDX. Textures could be best documented using EBSD imaging where grain boundaries of forsterite became clearly visible compared with normal back-scattered electron images that only showed cracks. From EBSD pictures showing Fe-Si alloys at well-equilibrated forsterite triple junctions dihedral angles were determined. For assemblages of forsterite and Fe-rich liquid dihedral angles are 112^o for $Fe_{91}Si_9$ and 107^o for $Fe_{83}Si_{17}$. We conclude that Si has virtually no influence on interfacial energies between liquid Fe and forsterite. It is, therefore, unlikely that Si solubility aided porous flow and led to efficient core formation on relatively reduced planetary bodies.