

Melting experiments on Fe–Si–S alloys to core pressures: Silicon in the core?

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ABSTRACT

Melting and subsolidus experiments were carried out on Fe–Si–S alloys (2.2–2.7 wt% Si + 2.0–2.1 wt% S) up to 146 GPa in a laser-heated diamond-anvil cell (DAC). The melting and subsolidus phase relations were examined on the basis of in situ synchrotron X-ray diffraction measurements and ex situ textural and chemical characterizations of recovered samples. The subsolidus phase assemblage changed from Fe-rich hexagonal closed-packed (hcp) phase + Fe₃S into a single phase of hcp Fe–Si–S alloy above 80 GPa at ~2500 K. The melting curve was obtained on the basis of the appearance of diffuse X-ray scattering and/or melting texture found in the cross section of a recovered sample. Microprobe analyses of quenched molten samples showed that liquid Fe–Si–S coexisted with Fe-alloy solid, which is depleted in sulfur but enriched in silicon compared to the liquid. This result indicates that the liquid evolves toward a Si-poor and S-rich composition upon crystallization. Our data further suggest that the ternary eutectic liquid composition is Si-deficient and close to the tie line between the eutectic points in the Fe–Si and Fe–S binary systems at each pressure. The composition of Fe–Si–S liquid that accounts for the outer core density is outside the liquidus field of solid Fe at the inner core boundary (ICB) pressure. Accordingly, the solid alloy crystallizing from such an outer core liquid must be more enriched in silicon/sulfur than the coexisting liquid and thus cannot form the denser inner core required from seismic observations. Furthermore, neither liquid Fe–Si–C nor Fe–Si–O can crystallize a dense solid at the ICB.

These results reinforce the conclusion that silicon is not an important light element in the core.

Keywords: Core, light element, silicon, sulfur, high pressure, melting