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Melting Behavior of Fe-Si-H and its Impact on Possible Stratification at the Topmost Outer Core

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Seismic studies have found that the topmost 100-km of the outer core displays up to 1.2% decrease in velocity (E' layer) [1]. A decrease of a single light element in Fe alloy could explain the observed low velocity [2]. However, such a decrease would lead to a density increase, resulting in dynamic instability of the stratification [2]. H and Si are important light element candidates in the Earth's cores (~0.6 wt% H and ~13 wt% Si) [3] and therefore melting behavior of Fe-Si-H provides important insights into understanding the E' layer. We have conducted a series of melting experiments on Fe-Si alloy with 9 wt% Si in H up to 125 GPa and 3700 K in laser-heated diamond-anvil cells. Synchrotron X-ray diffraction characterizations show that the quenched product consists of B2 FeSi and FeH_x, which are the liquidus phase and quenched melt, respectively. Furthermore, the B2 phase crystallized from Fe-Si-H melt has a Fe:Si ratio of nearly 1:1. This is contrast with H-free low-Si Fe-Si systems, where B2 phases should have low Si contents [4]. The observation suggests that H alters Si partitioning between Fe liquid and solid. The elevated Si in the B2 phase would increase melting temperature and thus result in its crystallization at the topmost outer core. The Si-rich B2 phase would be buoyant because of its low density. Consequently, it would float toward the core-mantle boundary leaving the topmost outer core depleted in Si but enriched in H. Such a low-Si, high-H region could have low density and velocity, consistent with dynamic stability and seismic observations of the E' layer. The FeSi sediments at the core-mantle boundary may form thin high-density, low-velocity structures, providing explanations for ultra-low velocity zones and core rigidity zones in the region.

[1] E. J. Garnero, D. V. Helmberger & S. P. Grand (1993), *Geophys. Res. Lett.* 20, 2463–2466.

[2] J. Brodholt & J. Badro (2017), *Geophys. Res. Lett.* 44, 8303–8310.

[3] K. Hirose, B. Wood & L. VoÄ adlo (2021), *Nature Reviews Earth & Environment* 2, 645–658.

[4] R. A. Fischer *et al. (2014)*, J*ournal of Geophysical Research: Solid Earth* 119, 2810–2827.