Melting in the Fe–O–S System at High Pressure

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The cores of Earth and the other terrestrial planets are composed of iron alloys with light elements such as O, S, Si, and/or C, and therefore the phase relations of these iron-rich systems are essential to understanding the structure, composition, and evolution of planetary cores. Binary Fe-X phase diagrams are largely established up to approximately Earth's core-mantle boundary pressures at least, but the relevant ternary and higher order phase equilibria are less well understood. Here we present phase relations, including melting, on the Fe–O–S system that may be important to planetary cores, including Earth's. We performed synchrotron X-ray diffraction experiments to monitor the phases present in Fe:FeO:FeS mixtures to >60 GPa. The onset of melting was determined by the appearance of diffuse scattering in the X-ray diffraction patterns. For Fe-rich compositions with a 1:1 FeO:FeS ratio, FeO diffraction peaks vanished upon melting and those from Fe_3S persisted, indicating that the high pressure eutectic lies on the FeO-rich side of this composition. Melting in the Fe–O–S compositions studied occurs at temperatures indistinguishable (within ~100 K) from the Fe–Fe_3S eutectic melting curve [1]. Building upon earlier work on the binary melting behavior (e.g., [1–3]), these results help define the ternary Fe–FeO–FeS system under *P,T* conditions relevant to terrestrial planetary cores. Compared to the melting curve of pure Fe, the melting point depression at lower mantle / outer core pressures can vary widely depending on whether the dominant light element is sulfur (1200–1300 K) [1], oxygen (400–500 K) [2], or silicon (300–500 K) [3]. Consequently, the uncertainty in the light element composition of the outer core alone presents an uncertainty of approximately ±500 K to the geotherm in the core.

[1] Kamada *et al* (2012) *Earth Planet. Sci. Lett.* **359-360**, 26–33 [3] Seagle *et al* (2008) *Earth Planet. Sci. Lett.* **265**, 655–665 [4] Fischer *et al* (2013) *Earth Planet. Sci. Lett.* **373**, 54–64