Liquidus Curves of the Fe-S System, Implications for Planetary Core Solidification

Allison Pease and Jie (Jackie) Li

University of Michigan-Ann Arbor

apease@umich.edu and jackieli@umich.edu

The Fe-S system is commonly used as a compositional analog for the cores of terrestrial bodies. Thus, knowledge of iron-rich liquidus curves at high pressures is key to understanding the thermal and chemical evolution of Earth and planetary cores. Previous studies have investigated the melting behavior of the Fe-S system at pressures analogous to the core of Mars/Mercury, but the predicted liquidus temperatures at 14-23 GPa differ by as much as 200 K (Fei et al., 2001; Stewart et al., 2007; Chen et al., 2008). Chen et al. (2008) reported that the Fe-S system had two inflection points at 14 GPa. Inflection points were also predicted to occur at 20 GPa (Pommier et al., 2018), but the liquidus is predicted to behave ideally at 21 and 23 GPa (Fei et al., 2001; Stewart et al., 2007). The change in the shape of the liquidus curve between 20 and 21 GPa results in a large temperature discrepancy at certain sulfur contents. In this study, we conducted multi-anvil experiments at 14 and 24 GPa between 1200-2000 ˚C, in order to determine the liquidus curves of the Fe-S system on the iron-rich side of the eutectic point (up to ~16 weight percent S). Our results confirm the existence of the two inflection points observed by Chen et al., (2008), suggesting that the presence of inflection points applies to all pressures between 14 and 24 GPa. The shape of the Fe-S liquidus curve implies that the Martian and Mercurian cores undergo solidification via iron snow for low sulfur concentrations and Fe_3S solidification for high sulfur concentrations. At low sulfur concentrations the Martian core is expected to solidify around 25 GPa, below the core-mantle boundary, whereas the Mercurian core solidifies in multiple locations due to the ideal behavior of the Fe-S liquidus at 10 GPa. Considering the non-ideal liquidus curve with inflection points, the Martian and Mercurian core likely solidify at lower temperatures than predicted by the assumed ideal liquidus curve.