Phase relations in the Fe-FeSi system at 10 GPa : Implications for Mercury’ s core

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Mercury’ s magnetic field, which shows dipole, has been observed by Mariner 10. Core dynamo is the most reliable model for generating the dipolar magnetic field. A high electrical conductive fluid, i.e., a liquid core, plays an important role for generating the core dynamo. Assuming the pure iron core, the present core would be completely solidified based on the Mercury’ s thermal history. Therefore, other factors are needed to maintain the molten Mercury’ s core. One of the most plausible factor is a depression of the melting point of pure Fe core due to dissolving light elements. Recent studies have suggested that Mercury’ s core may contain several wt% silicon based on high-pressure experiments. Therefore, the melting relations of the Fe-FeSi system at high pressures can provide knowledge of the Mercury’ s core structure. However, high-pressure phase relations of this system are not yet known precisely. In order to get the better understanding of the core structure, it is needed to perform melting experiments under the core conditions.
In this study, we determined the phase diagram for the Fe-FeSi system at a pressure of 10 GPa and temperatures between 920 ℃ and 1800 ℃ based on in-situ X-ray and quenched experiments using a Kawai-type multi-anvil apparatus. Our results showed that the system had two eutectic points at approximately 10 wt% Si and 20 wt% Si and sub-solidus phases are fcc-Fe (<10 wt% Si) and Fe_3Si (10-20 wt% Si) and FeSi (>20 wt% Si). Based on our results, we suggest three models of Mercury’ s core evolution depending on the initial core composition.

Keywords: Mercury’ s core, Iron-silicon alloys, Phase diagram, High pressure