Melting relations in the Fe-P system at high pressures

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The present-day temperature profile of the Earth's core is key to understanding of the thermal history and dynamics of the core. The temperature in the outer core region is over the melting temperature of the core material and crossovers it at the inner-outer core boundary. Thus, the melting temperature of the core material under relevant high-pressure conditions is crucial to constrain the core temperature. It is well known that the core is composed mainly of Fe, but including 10% lighter elements [1], though the nature of the light elements is still unclear. Phosphorous is also one of the candidates for the core light elements because it is found in iron-meteorites [2] and depleted in the silicate mantle relative to chondrites [3]. In this study, we performed melting experiments on Fe_3P up to 80 GPa by using a laser-heated diamond anvil cell.

The melting relation was determined from in-situ X-ray diffraction measurements at the beamline BL10XU of the SPring-8 synchrotron facility. During heating, we observed a peritectic melting of Fe_3P to liquid + Fe_2P and complete melting up to 60 GPa. The onset and complete melting of the sample were judged from the intensity of diffuse scattering signals from the liquid. This melting phase relation was also confirmed from the chemical analysis on some recovered samples. Above 60 GPa, we observed the change in diffraction pattern of the Fe_3P sample at subsolidus temperature conditions, which might be the decomposition to iron-rich and Fe_2P phases. For this two-phase mixture, we also determined the solidus and liquidus temperatures. In the present experimental pressure conditions, the peritectic (or solidus) and liquidus temperatures of the Fe_3P composition are ~700 K and ~200-300 K lower, respectively, relative to the melting temperature of Fe [4]. These indicate that phosphorous reduces strongly the melting temperature of Fe.

References

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