Chemical and physical properties and thermal state of the core and lower mantle

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Recent advance in high pressure mineral physics revealed several new phase transitions in the lower mantle such as spin transitions (e.g., [1]) and post-perovskite transition (e.g., [2]). Spin transitions in the lower mantle phases has some effects on the seismic wave velocities [3] and the Mg-Fe partitioning between the phases [4]. The post-perovskite transition may be important to account for the seismic anomaly in the D" layer. The transition boundary can constrain the seismic structure at the base of the lower mantle, i.e., a double crossing of the post-perovskite phase boundary, thus it can constrain the temperature of the CMB region [5].

It has been suggested that the density of the core is lower than the density of pure iron under the conditions of the core, whereas V_p of the core seem to be higher than that of molten iron and solid iron. Therefore, light elements such as H, C, S, O, or Si may exist in the core [6]. Intensive efforts have been made to clarify the melting curves of iron [7], Fe-Si [8], and Fe-S systems [9] up to 135 GPa. These melting curves can provide a constraint for the temperatures at ICB and CMB. Compression curves of iron alloy melts such as Fe-Si, Fe-S, Fe-C melts have been measured to c.a. 5 GPa [10]. Si might be a plausible light element in the outer core, since it reduces the density of liquid iron and increases V_p of liquid iron. S and C seem to reduce V_p of liquid iron, although the structure of the Fe-S melt might be similar to that of the Fe-Si melt at high pressure [10]. The non-ideality of Fe-S and Fe-Si melts cannot be ignored to estimate the amount of light elements in the outer core based on the density deficit, since negative volume of mixing of these melts are observed at high pressure [11].

The structure of the inner core phase is a matter of debate. The stability of iron alloys has been studied up to c.a. 300 GPa and 3500K. Several authors suggested the hcp-phase is stable in the inner core, such as Fe and FeNi alloy [12], FeSi alloy [13], whereas the bcc phase is reported to be stable under the core conditions [14]. Further studies under the inner core conditions are needed. Sound velocity measurements of Fe alloys at high pressures have been conducted by IXS [15] and NRIXS [16] using synchrotron X-ray. There are inconsistencies between the sound velocities of hcp-Fe determined by the two methods regarding the temperature effect of the Birch's law [16]. hcp-FeNiSi alloy can account for both density and V_p of the inner core [17]

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