Effect of silicon on viscosity of ε-iron

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The inner core is mainly thought to be composed of Fe-Ni alloy with hcp structure based on the high pressure experiments (Tateno et al., 2012) and hence the physical properties of hcp iron (ε-iron) are keys for understanding the dynamics of the inner core. Seismic observations suggest the variation in the seismic attenuation between the western side and eastern side of the inner core (Monnereau et al., 2010). It is important to understand the reason why such variation is formed for the constraint on dynamics of the inner core. One possibility is the effect of light element containing in the inner core on the physical properties of hcp iron. Because seismic attenuation is strongly related to rheology of constituting materials, the investigation of the effect of light element on viscosity of ε-iron is a key if chemical heterogeneity of light element exists between the western side and eastern side of the inner core. In this study, therefore, we determine the effect of light element of silicon on viscosity by means of deformation experiment at high pressure.

We conduct in situ high pressure experiments to determine the relative viscosity between pure iron and Si alloying iron at the stability field of ε-iron iron. We used polycrystalline Si-free and 3 wt % bearing irons couple as starting material. In the high pressure experiment, the starting materials was compressed in a cubic type high pressure cell in a deformation-DIA type apparatus at BL04B1, Spring-8. At the pressure of ~5 GPa, sample was repeatedly heated to ~1000 K and quenched to room temperature across the phase boundary between bcc and fcc iron to obtain the equigranular texture due to phase change. Then subsequently sample was deformed at ~12 GPa with ε-iron structure. Stress and strain were measured by X-ray diffraction and X-ray radiography, respectively.

Preliminary results suggest that the effect of silicon on viscosity is small, indicated by the comparable strain between Si-free and 3 wt % bearing irons at the experimental condition, strain rate of 10^{-3}-10^{-4} /s, stress level of ~1 GPa and strain up to ~10 %. If we simply apply this preliminary result, the variation in the observed seismic attenuation may not be explained by alloying by silicon and alternative such as partial melting or pre-melting should be considered.

