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ε 鉄の粒成長と内核のダイナミクス
Inner core dynamics inferred from grain growth of epsilon-iron

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The inner core is 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 (epsilon-iron) are keys for understanding the dynamics of the inner core. Recent seismic observations suggest the variation in grain size in the inner core (Monnereau et al., 2010). It is important to understand the variation in grain size for constraints of the dynamics of the inner core because grain size is controlled by the growth rate and growth rate gives us information on time scale of the inner core growth and/or deformation. In this study, we experimentally determine the grain growth rate of epsilon-iron to understand the dynamics of inner core.

epsilon-iron is only stable at high pressure and it is unquenchable to an ambient condition. Therefore, in this study, we conduct in situ high pressure experiments to determine the grain growth rate of epsilon-iron. We prepared polycrystalline iron of starting material by multi-directional forging (MDF) on highly purity iron rod to avoid oxidation during sintering. In the high pressure experiment, the starting materials was compressed in a Kawai-type high pressure apparatus equipped with sintered diamond anvils with 1.0 truncated edge length at BL04B1, SPring-8. At the pressure of 50-60 GPa, sample was heated for several hours to determine the grain growth rates. Grain growth can be detected by the reduction of number of diffraction spots on the two-dimensional detector with monochromatic X-ray (Offerman et al., 2002) with annealing time.

In the experiments, we observed the reduction of the number of diffracted spots, meaning that grain growth occurs during annealing experiments. For example, the number of diffraction spots reduced to 50 % after annealing at 1300 K for two hours. By extrapolating the present data, we may constrain the translation dynamics of the inner core (Alboussiere et al., 2010) in comparison with seismic observation.

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Alboussiere, T., Deguen, R., Melzani, M. (2010) Melting-induced stratification above the earth's inner core due to convective translation, Nature, 466, 744-747.

Offerman, S. E., van Dijk, N. H., Sietsma, J., Grigull, S., Lauridsen, E. M., Margulies, L., Poulsen, H. F., Rekveldt, M., van der Zwaag, S. (2002) Grain nucleation and growth during phase transformations, Science, 298, 1003-1005.

Tateno, S., Hirose, K., Komabayashi, T., Ozawa, H., Ohishi, Y. (2012) The structure of Fe-Ni alloy in earth's inner core, Geophy. Res. Lett., 39, L12305.