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学位論文の題目	Experimental study on rheology of deep mantle minerals （マントル深部鉱物レオロジーの実験的研究）
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学位論文内容の要旨

Seismological and geochemical evidence indicates the subduction of silica rich layers, i.e. subducted sediment, MORB layers, and possible entrained primordial continents, into the deep mantle. The subducted silica rich layers may delaminate at the bottom of mantle transition zone, where silica will be stable as stishovite. Stishovite is highly elastic anisotropy and has high potential to be responsible for the observed seismic anisotropy. Therefore, I experimentally deformed stishovite aggregate at 12 GPa and 1600 ℃. The dominant slip system in stishovite was suggested to be [001] {110}. The observed faster vertically polarized shear wave anisotropy in the mantle transition zone can't be explained by stishovite with horizontal flow. This may indicate the penetration of silica rich layers into the lower mantle, i.e. sinking into D″ layer or stagnating in the lower mantle. I conducted deformation experiment on α-PbO_2, which is the analog of seifertite, the stable phase of silica in D″ layer. Preliminary results indicate dominant slip system of [100] (010). The observed faster horizontally polarized shear wave polarization anisotropy in D″ layer can't be explained by seifertite with horizontal flow. My results indicate the possible stagnation of silica rich layers in the lower mantle. The seismologically observed seismic reflectors in the mid-mantle were proposed to be the subducted silica rich layers. To check the stability of seismic reflectors in the convecting mantle, I determined the Si and O self-diffusion in stishovite simultaneously up to 21.5 GPa and 2073 K by means of the isotopic tracer method adopting single crystals. The results indicate the preservation of seismic reflector in the vigorous convecting mantle is supported by the high viscosity of stishovite inferred from slow Si diffusion. What's more, I hold great interest in the deformation of lower mantle bridgmanite and ferropericlase two-phase composite. I optimized Kawai-type cell assembly (6–8 type) for deformation-DIA and DT-Cup deformation apparatus. I firstly reached lower mantle conditions with DT-Cup apparatus. Deformation experiments on aggregates of bridgmanite and post-spinel two-layered sample were conducted up to strain of 0.2. Present development demonstrates an approach of using DT-Cup to study the rheology of lower mantle minerals.

論文審査結果の要旨

Rheological properties of mantle constituting minerals in the Earth are key to understand the mantle flow which is strongly related to phenomena observed on the Earth's surface such as earthquake, volcanic activity and so on. In this study, Fang Xu studied on the rheological properties of mantle minerals to apply the dynamic of Earth's deep interior by means of high pressure experiments.

This thesis is composed of three sections. In the first part, the pattern of the lattice preferred orientation (LPO) of stishovite (SiO_2) formed during deformation at high pressure was determined. Because stishovite is one of the main constituting mineral of the oceanic crust in the subducting slab, it is concluded that the stagnation of large amount of oceanic crust in the lower mantle transition zone is unlikely at least as horizontal layer based on the comparison of the LPO pattern with the observation of seismic anisotropy. Then, in the second part, Si and O diffusions in stishovite were determined to estimate the viscosity of stishovite. The results show that the viscosity of stishovite is 3-4 orders of magnitude higher than that of bridgmanite, which is the most dominant mineral in the lower mantle. This high viscosity indicates the highly possibility of the preservation of the subducted oceanic crust from mixing with the bridgmanite ($(Mg,Fe)SiO_3$)-rich surrounding mantle for the geological time scale. The preserved oceanic crust is considered to be observed as seismic reflector in the upper lower mantle. Implications based on the experimental results on LPO and diffusion play important role to constrain the fate of subducting slab. In the third part, the experimental technique was developed to deform minerals under the lower mantle conditions. Using this technique, then, the relative viscosity of the lower mantle mineral assembly (bridgmanite and ferropericlase ((Mg,Fe)O)) were determined. The viscosities of the single phase of bridgmanite and the aggregates of bridgmanite plus ferropericlase showed the almost identical viscosity, providing the important constraint on the consideration of the viscosity variation in the lower mantle.

We considered that this thesis contains the important results on the Earth science. Therefore, we concluded that this thesis is proper to be accepted as a dissertation of Ph. D. of Okayama University.