氏　　名	管　隆莉
授与した学位	博　士
専攻分野の名称	理　学
学位授与番号	博甲第　　６８５１　　号
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学位授与の要件	自然科学研究科　　地球惑星物質科学専攻 （学位規則第４条第１項該当）
学位論文の題目	Experimental investigations of the rheological properties of mantle minerals （マントル鉱物の実験的レオロジー研究）
論文審査委員	教授　神崎　正美　　教授　田中　亮吏　　教授　芳野　極 准教授　山﨑　大輔　　教授　David Robson

学位論文内容の要旨

Seismic anisotropy has significant implications for understanding the Earth's mantle dynamic process and it has been observed in the lower mantle transition zone (MTZ). The seismic anisotropy can be often caused by lattice preferred orientation (LPO) of elastically anisotropic minerals. LPO of akimotoite is plausible to interpret these seismological observations because it is highly elastically anisotropic and it is one of the main constituting minerals in the lower MTZ. To observe the LPO of akimotoite developed during deformation, I conducted the well-controlled uniaxial and shear deformation experiments on the $MgSiO_3$ akimotoite aggregates at 21-23 GPa and 900-1300℃ by using the D111 apparatus. The most dominant slip system of akimotoite is $<10\bar{1}0>$ (0001). The velocities of horizontally polarized shear waves are greater than the velocities of vertically polarized shear waves for horizontal mantle shearing. The LPO of akimotoite formed by slab-induced mantle flow can well explain the reported *S*-wave polarization anisotropy near the subducting slabs in the lower MTZ. Moreover, the LPO of akimotoite would contribute to the observed azimuthal anisotropy near the subducting slabs in the mantle transition zone.

In the Earth's lower mantle, bridgmanite is the most abundant mineral in the pyrolitic mantle model, the rheological properties of which are expected to control the lower-mantle dynamics. Bridgmanite can incorporate Al and Fe, which may affect its rheological properties. Therefore, I conducted the uniaxial deformation experiments on pure bridgmanite and Al/Fe-bridgmanite by using the D111-type apparatus at a pressure of 25 GPa and temperature of 1700-2100 K to investigate the effect of Al with Tschermak (TS) substitution and oxygen-vacancy (OV) substitution and Fe with different Fe^{3+}/total Fe ratios on the rheological properties of bridgmanite. The deformation behaviors of OV and TS bridgmanite were quantitatively determined in the form of a flow law. The creep strength of OV bridgmanite was almost same as that of pure bridgmanite (variation was less than 0.05 log unit), while the TS bridgmanite was slightly harder than pure bridgmanite (variation was less than 0.2 log unit) under the present experimental conditions. The Fe^{2+}-rich bridgmanite was a little bit harder than pure bridgmanite and harder than Fe^{3+}-rich bridgmanite. However, the maximum viscosity contrast was within one order even if we considered the error. Based on our result of a small rheology contrast between pure bridgmanite and Al/ Fe -bearing bridgmanite (less than one order), we conclude that the chemical variation does not affect too much the viscosity of bridgmanite. The viscosity of the lower mantle would be quite uniform if the rheology of the lower mantle is dominantly controlled by bridgmanite, which is consistent with the geophysical observations.

論文審査結果の要旨

Ph. D defense for Ms. Longli GUAN was held on 13th February, 2023.

Rheological properties of mantle minerals are important factor to understand the mantle dynamics and mantle convection, because the many events observed on the Earth's surface such as earthquake, volcanic activity and so on are strongly related to the mantle convection. In Longli GUAN's study, rheological properties of mantle minerals to apply the dynamic of Earth's deep interior are investigated by means of high-pressure experiments.

Her thesis is composed of two sections.

In the first part, Longli GUAN investigated the plastic flow in the lower mantle transition zone where seismic anisotropy is widely observed. Because lattice preferred orientation (LPO) of akimotoite is a strong candidate in the cold region of the mantle transition zone to explain the elastic wave anisotropy because the other minerals (ringwoodite and majorite) are elastically isotropic, she conducted deformation experiments on akimotoite at 21-23 GPa and 900-1300 degree C by using recently developed D-111 type deformation apparatus. The results provide important implications for the origin of seismic anisotropies and the mantle flow direction in the mantle transition zone.

Then, in the second part, Longli GUAN investigated the Al and Fe effects on the rheology of bridgmanite which is the most abundant mineral in the lower mantle to consider the viscosity variation in the lower mantle. She determined relative viscosities of Al- and Fe-bearing bridgmanite against pure ($MgSiO_3$) bridgmanite at ~24 GP and 1700-2100 K by deformation experiments using D-111 type apparatus at the synchrotron facility for in-site X-ray observation and our lab. (IPM, Okayama Univ.) for ex-site experiments. Experimental results show the important result on the mantle dynamics to be small effects of Al and Fe on the viscosity, indicating the uniform viscosity model in the lower mantle suggested by geophysical observation is preferred rather than large variation of viscosity model.

We considered that Longli GUAN overcame the experimental difficulty and obtained the important results on the Earth science, especially on mantle rheology. Therefore, we concluded that this thesis is proper to be accepted as a dissertation of Ph. D. of Okayama University.