Japan Geoscience Union Meeting 2015
(May 24th - 28th at Makuhari, Chiba, Japan)

SIT03-12 会場:106 時間:5月25日 17:15-17:30

Effect of Al content on electrical conductivity of bridgmanite
Effect of Al content on electrical conductivity of bridgmanite

芳野 極 [1*] ; 鎌田 誠司 [2] ; 大谷 栄治 [2] ; 平尾 直久 [3]
YOSHINO, Takashi[1*] ; KAMADA, Seiji[2] ; OHTANI, Eiji[2] ; HIRAO, Naohisa[3]

[1] 岡山大学地球物質科学研究センター, [2] 東北大学, [3] 高輝度光科学研究センター
[1]Institute for Study of the Earth's Interior, Okayama Univ., [2]Tohoku Univ., [3]JASRI

Electrical conductivity is one of useful methods to prove temperature, structure and composition of the Earth's deep interior. Interpretation of electrical conductivity in the Earth has been done by comparison between conductivities obtained from geophysical observations and conductivities measured in the laboratory. Because bridgmanite is believed to be a dominant constituent mineral in the lower mantle, knowledge of electric conduction for bridgmanite to constrain the conductivity profile of the lower mantle. Xu et al. (1998) reported that Al incorporation to bridgmanite enhance the electron hopping conduction. Although there is a large variation of Al content in bridgmanite under the lower mantle, electrical conductivity of aluminous bridgmanite have not been measured as a function of Al content.

In this study, Impedance spectroscopy measurements were performed at 26 or 28 GPa and up to 2000 K in a Kawai-type multi-anvil apparatus in order to investigate effect of aluminium content on electrical conductivity of bridgmanite. The starting materials were synthetic orthopyroxene $(Mg_{0.9}, Fe_{0.1})SiO_3$ powders with various amounts of aluminium (Al_2O_3 = 3, 6 and 10 wt.%). Electrical conductivity of aluminous bridgmanite increases with increasing Al content. At temperatures below 1700 K, the activation enthalpies of these samples are around 0.4 eV, which is consistent with that reported by Shankland et al. (1993), who measured the conductivity of quenched perovskite. At higher temperatures ($>$1800 K) corresponding to temperature conditions of the uppermost lower mantle, the conductivity of samples with relatively lower Al content abruptly increases with temperature and the resultant activation enthalpy is around 1 eV, which is consistent with that reported by Dobson (2003). At temperatures below about 1700 K, small polaron (electron hole hopping between ferrous and ferric iron sites) conduction with activation energy of 0.4 eV is considered as a dominant conduction mechanism of aluminous bridgemanite. At higher temperatures, a different conduction mechanism dominates with more than1 eV of activation enthalpy.

To estimate ferric iron content in bridgmanite, synchrotron Mossbauer spectroscopy was performed at SPring-8 BL10XU. The ferric iron contents of all samples are estimated to be more than 60 % against total iron content. Proportion of ferric iron in A site tends to increase with increasing Al contents. Thus, increase of ferric iron content due to Al incorporation into bridgmanite can induce enhancement of conductivity. At high temperatures above 1800 K, the dominant conduction mechanism can change extrinsic oxygen ionic conduction when Al_2O_3 content is low. Xu and McCammon (2002) reported evidence that in aluminous perovskite with Mg#90, ionic conduction characterized by high activation energy (1.5 eV) becomes significant above 1700 K dependent on Al content. This is most likely due to the presence of oxygen vacancies, which charge-balance Al and ferric iron substituting onto the B site (Brodholt 2000; Lauterbach et al. 2000). The present results suggest that the electrical conductivity of a region at the top of the earth's lower mantle could be sensitive to amount of Al content in bridgmanite. On the other hand, when Al content in bridgmanite is low, the lower mantle conductivity will be more sensitive to temperature due to the extrinsic oxygen ionic conduction.

References

Brodholt, J.P., Nature 407, 620?622, 2000.
Dobson, D., 2003. Phys. Earth Planet. Inter. 139, 55-64, 2003.
Lauterbach, S., C. A. McCammon, P. van Aken, F. Langenhorst, F. Seifert, Contrib. Mineral. Petrol., 138, 17? 26, 2000.
Shankland, T.J., Peyronneau, J., Poirier, J.-P., Nature 366, 453?455, 1993.
Xu, Y., McCammon, C., Poe, B.T., Science282, 922?924, 1998.
Xu, Y., C. McCammon, J. Geophys. Res., 107, 2251, 2002.

キーワード: ブリッジマナイト, 下部マントル, 電気伝導度, メスバウア分光, Al, 電子ホッピング
Keywords: bridgmanite, lower mantle, electrical conductivity, Mosbauer spectrocopy, Al, electron hopping