Effects of chemical composition and melting on viscosity and electrical conductivity of synthesized lherzolite.

*Kenta Sueyoshi[1], Takehiko Hiraga[1]

1.Earthquake Research Institute, The University of Tokyo

Viscosity and electrical conductivity of the mantle are considered to be sharply changed at around solidus temperature during ascend of the mantle. In order to evaluate the melting effects on such physical properties of ascending mantle (ex. beneath mid-ocean ridge), we monitored the viscosity and electrical conductivity of synthesized lherzolite aggregates during raising temperature from well below solidus temperature under atmospheric pressure.
We synthesized Fe-free lherzolite aggregates composed of forsterite (fo), enstatite (en), diopside (di) and anorthite (an) from $Mg(OH)_2$, SiO_2, $CaCO_3$ powders with particle size of <50 nm and spinel powders with particle size of ~200nm. By changing the amount of spinel, we controlled fraction (φ) of incipient melt ranging from 0.005 to 0.06. Samples were sintered at temperature below solidus (~ 1230°C) to prepare melt-free aggregates before experiments.
We found two types of chemical effects on subsolidus condition. The spinel-added samples exhibited about an order of magnitude lower viscosity compared to spinel-free samples. Fo + en + di and fo + en samples (Tasaka et al., 2013) exhibited the similar viscosity. Further, fo + en + spinel samples and fo + en + di + an samples exhibited the similar viscosity indicating that small amount of Al at grain boundaries or grain interior increases creep rate of the aggregates. Electrical conductivities of all diopside-bearing samples were higher than the conductivity of fo + en sample. No dependency of electron conductivity on grain size was detected for diopside-bearing samples indicating that Ca at grain interior of forsterite enhanced the electrical conductivity. During crossing solidus temperature, the samples with the lowest incipient melt fraction ($\varphi = 0.005$) showed a gradual decrease in viscosity and gradual increase in electrical conductivity whereas larger incipient melt fraction ($\varphi = 0.04$) samples showed step-wise decrease and increase in viscosity and electrical conductivity, respectively. The melt effect on viscosity could be expressed in empirical expression of $\eta \propto \exp(\alpha\varphi)$ where $\alpha = 69$. This value is considerably larger than the value ($\alpha = 21$) previously proposed from creep experiment of synthesized lherzolite aggregates using natural minerals, (Zimmerman and Kohlstedt, 2004).

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