Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

SIT02-22 Room:104 Time:May 22 13:45-14:00

Electrical conductivity of volatile-bearing partial molten peridotite

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The softness of oceanic asthenosphere that allows mobility of overlying lithosphere has been explained by partial melting, hydrolytic weakening of the constituent minerals or just high temperature. Electrical conductivity is a key physical valuable to examine these hypotheses.Recent laboratory electrical conductivity measurements have shown that proton conduction in olivine can elevate the electrical conductivity compared to the dry condition. However, the latest two studies have shown that electrical conductivity of hydrous olivine is not high enough to explain the conductivity anomaly at the top of the asthenosphere, even if the olivine crystal contain a certain amount of water.

Partial melt is the most attractive agent to raise the conductivity at that depth. Recent geoelectromagnetic studies showed conductibility structures of the upper asthenosphere under the Pacific Ocean and required high melt fraction (˜2 vol. %) in the presence of the anhydrous basaltic melt, which is not consistent with the melt fraction estimated from the seismic studies. Volatile components such as water and carbon dioxide in partial molten peridotite can largely reduce the melting temperature and can largely increase the conductivity. However, there have been no systematic study for electrical conductivity of volatile-bearing partial molten peridotite.

In the present study, effect of volatile components such as H2O and CO2 on electrical conductivity of the partial molten peridotite was investigated to consider as a cause of the high conductivity anomaly. The starting materials were KLB1 + 2 wt.% H2O and KLB1 + 1.5 wt.% CO2. The electrical conductivity measurements were performed at 3 GPa and various temperature conditions to obtain a vriation of melt fraction. We found that water- and carbonate-rich partial melts have extremely high conductivity. Electrical conductivity of hydrous partial molten peridotite showed huge enhancement of the conductivity (more than three orders of magnitude) just above the solidus. The conductivty decreased with increasing both temperature and melt fraction. This trend implies that the conductivity decreases with decreasing water conetnt in partial melt. Electrical conductivity of partial molten carbonate peridotite showed that the conductivity of the carbonate melt is nearly one order of magnitude higher than those of silicate melt in peridotite. The high conductivity of the upper asthenosphere beneath the young oceanic lithosphere is not caused by mineral hydration, but by presence of trace amount of volatile-rich melt due to trace amount of volatile components in the asthesnospheric mantle.

Keywords: volatile component, electrical conductivity, partial melting, upper mantle, peridotite, water