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Electrical Conductivity of Partially Molten Peridotite Analogue Under Shear

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So far, two hypotheses have been proposed to explain softening of the oceanic asthenosphere allowing smooth motion of the oceanic lithosphere. One is partial melting, and the other is hydraulitic weakening. Although the hydraulitic weakening hypothesis is popular recently, Yoshino et al. [2006] suggested that this hypothesis cannot explain the high and anisotropic conductivity at the top of the asthenosphere near East Pacific Rise observed by Evans et al. [2005]. In order to explain the conductivity anisotropy over one order of magnitude by the partial melting hypothesis, we measured conductivity of partially molten peridotite analogue under shear conditions. The measured samples were mixtures of forsterite and chemically simplified basalt. The samples were pre- synthesized using a piston-cylinder apparatus at 1600 K and 2 GPa to obtain textural equilibrium. The pre-synthesized samples were formed to a disk with 3 mm in diameter and 1 mm in thickness. Conductivity measurement was carried out also at 1600 K and 2 GPa in a cubic-anvil apparatus with an additional uniaxial piston. The sample was sandwiched by two alumina pistons whose top was cut to 45 degree slope to generate shear. The shear strain rates of the sample were calibrated using a Mo strain marker in separate runs. The lower alumina piston was pushed by a tungsten carbide piston embedded in a bottom anvil with a constant speed. Conductivity was measured in the directions normal and parallel to the shear direction simultaneously. We mainly studied the sample with 1.6 volume percent of basaltic component. The shear strain rates were 0, 1.2×10^{-6} and 5.2×10^{-6} /s. The sample without shear did not show conductivity anisotropy. In contrast, the samples with shear showed one order of magnitude higher conductivity in the direction parallel to the shear than that normal to the shear. After the total strains reached 0.3, the magnitude of anisotropy became almost constant for both of the strain rates. The magnitude is thus independent of the strain rate. This study demonstrates that the anisotropy at the top of the asthenosphere can be explained based on the partially molten asthenosphere sheared by the plate motion.