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In-situ electrical conductivity measurement of serpentinite during shear deformation

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Electrical conductivity anomaly has been found in mantle wedge above subducting slab (Yamaguchi et al., 2009). The subducting slab re-leases most of the water to the mantle wedge by the dehydration reactions, and the expelled water reacts with mantle rocks, forming serpentinite and minor amount of magnetite at the plate interface. Stesky and Brace (1973) reported that some serpentinites have high conductivity of 10^{-2} S/m even at room tempera-ture, and that the others have low conductivity of 10^{-5} S/m. Microstructural observations indicated that the observed high conductivity is caused by the intercon-nection of magnetite (10^{4} S/m) grains, which are pro-duced during serpentinization. However, magnetite distribution and precipitatation mechanism should be considered to extrapolate laboratory conductivity data of a few millimeter sized sample to several kilometers geological scale (Watanabe, 2005). Then we inferred that the deformation controls interconnection and ori-entation of magnetite in serpentinites, because the mantle wedge rocks at the plate interface are subjected to noncoaxial stress and widely develop a strong alignment of constituent minerals. Therefore, we de-signed experimental cell for the electrical conductivity measurement of during shear deformation, and discuss here the influence of strain and magnetite volume frac-tion on connectivity of magnetite.

The electrical conductivity meas-urements of serpentinites with various amount of magnetite were conducted using an impedance analyz-er under high pressure generated by a cubic anvil ap-paratus. The electrical conductivity of serpentinites was investigated in the frequency range of $10^{?1}$-106 Hz and temperature range of 500-750 K at 1 GPa along the shear direction. Starting materials were powder mixture of serpentine and magnetite. The mixed sam-ples were sintered in a piston cylinder apparatus at 1GPa and 500?C. The sintered materials were prepared to be 2 - 3 mm length and 0.8mm^{2} of cross-section area. (2.0 mm by 0.4 mm). The serpentinite sample was sandwiched between alumina pistons which were cut at 45^{o} from the maximum compression direction. Ni electrodes for the electrical conductivity measurement were placed at each side of sample and played a role as strain marker to assess the strain from rotation of boundary between sample and Ni. In shear defor-mation experiment, deformation rate was fixed to be 200 micrometer per hour for 8 hours.

We measured the electrical conductivity during heating from 500 K to 750 K. The conductivity values of the serpentinite were 10^{-3} to 10^{-2} S/m. In all experiments, logarithmic conductivity linearly increased and decreased with increasing and decreasing reciprocal temperature, and we obtained systematic results against volume fraction of magnetite. During shear deformation, electrical conductivity increased with increasing strain. Activa-tion energy did not change each samples before and after deformation.

The result showed that only the data of 20 vol. % magnetite content reach into value of conductivity anomaly in mantle wedge. It is difficult to explain electrical conductivity anomaly by deformation of nat-ural serpentinite, because magnetite content of natural serpentinite is generally less than 5 vol. %. Therefore a presence of free aqueous fluid with seawater-like composition would be required to explain high con-ductivity anomaly observed in the mantle wedge.

Keywords: Electrical conductivity, Serpentinite, Subduction zone, in-situ measurement, Magnetite