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The Standard Hydrous Olivine (SHO) conductivity model: A new tool for probing water in the upper mantle

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It has long been assumed that the incorporation of water in olivine has dramatic effects on the physical properties of the mantle, affecting large scale geodynamic processesand triggering most electrical conductivity anomalies in the mantle. But the conductivity models for hydrous olivine based on experimental measurements predict contrasting effects of water (e.g. Wang et al. 2006; Yoshino et al. 2009), precluding any unequivocal interpretation of electrical conductivities in the mantle. Our thesis is that the uncertainties and biases in the water contents of the olivines used for experiments were inappropriately appreciated, resulting in apparent incompatibilities when analysing the different datasets and in significant biases in the models outside of their range of calibration. Here, we analyse all published experimental work and provide a new model, SHO, that settles these major inconstancies. SHO is calibrated on the largest database of raw conductivity measurements on oriented single crystals and polycrystals of hydrous olivine, with water concentrations and temperatures spreading over 0-2220 wt. ppm and 200-1440˚C. Our model provides both oriented conductivities, allowing for calculating conductivity anisotropy, and isotropic conductivity, relevant for olivine aggregates without preferential orientation. SHO isotropic conductivity (S/m) is given by

$$\sigma = 10^{2.93} e^{-\frac{157000}{RT}} + 10^{-1.54} C_{H2O} e^{-\frac{87000 - 1820 C_{H2O}^{1/3}}{RT}},$$

where C_{H2O} is the water concentration in olivine (wt. ppm), T the temperature (K) and R = 8.314 J/K/mol. In the normally hot mantle, our model predicts a moderate effect of water on the conductivity of olivine. High conductivities ($\sim$ 0.1 S/m) are obtained at great depths and elevated water concentrations only ($>$ 350 km and $>$ 400 wt. ppm). The strongest effects are therefore expected in the coldest regions of the mantle, like cratonic lithospheres or subduction zones, where higher incorporation of water in olivine is allowed.

Wang, D., Mookherjee, M., Xu, Y., Karato, S. The effect of water on the electrical conductivity of olivine. *Nature* **443**, 977–980 (2006)

Yoshino, T., Matsuzaki, T., Shatskiy, A., Katsura, T. The effect of water on the electrical conductivity of olivine aggregates and its implications for the electrical structure of the upper mantle. *Earth Planet. Sc. Lett.* **288**, 291–300 (2009)