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# Correlations between electrical and elastic properties of solid-liquid composites with interfacial energy-controlled equilibrium microstructures

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Electrical conductivity and seismic velocity are studied for plausible pore geometries in the Earth's interior for reliable quantitative analysis of experimental data such as seismic tomography and magnetotelluric explorations. Electrical conductivity of a two-phase system with equilibrium, interfacial energy-controlled phase geometry is calculated for the dihedral angles $\theta$=40$^o$-100$^o$ that are typical for rock-aqueous fluid and $\theta$=20$^o$-60$^o$ for rock-melt systems of lower crust and upper mantle for the case of tetrakaidecahedral grains. The obtained conductivity is demonstrated to be in agreement with the experimentally measured electrical conductivities of a simple analog material, namely, of open cell metallic foam. Electrical conductivity vs. seismic velocity correlations are acquired by combining of the simulated electrical conductivities with the seismic velocity calculated with the help of equilibrium geometry model Takei (2002) for the same pore geometries. The results show that electrical conductivity gradually decreases reaching zero when seismic velocities reach seismic velocities of intact rock for rock-melt systems, while for rock-aqueous fluid systems with $\theta \geq 60^{\circ}$ conductivity drops to zero at velocities up to 10% smaller. This can explain the seeming discrepancy of the low seismic velocity region, attributed to the high fluid fraction, and the low electrical conductivity of the same region, which is sometimes faced at collocated electromagnetic and seismic experiments. The obtained electrical conductivity – seismic velocity correlations are shown to be practically important for the distinction between melt and aqueous fluid, for the precise definition of liquid fraction, and for the discrimination between regions in hydrostatic equilibrium and those which are subject to strong shear stress or slip process. The analysis on the basis of the calculated conductivity-velocity correlations of experimental electrical conductivity and seismic velocity tomography data allowed clarification the stress state in the region of the deep extension of an active fault. We investigated the area of the deep extension of the Nagamachi-Rifu by analysis of the data of collocated magnetotelluric and seismic velocity tomography results in comparison with the theoretical $\sigma$-$V$ correlations calculated for the equilibrium pore geometry. We suggested equilibrium stress state with the dihedral angles of 60-80$^{\circ}$ or weakly non-equilibrium stress state in the region located 0-20km to the northwest of M5.0 earthquake at the depth of 10-17 km and in the region extending 0-40km to the northwest of M5.0 at the depth of 18-30km on the basis of the analysis. Present study confirmed the non-equilibrium stress state suggested in the region located 20-40 km to the northwest from the hypocenter of M5.0 earthquake at the depth of 10-17 km. The electrical conductivity and seismic velocities data are shown to be complementary and be useful to clarify the stress state and specify the liquid fraction in the regions. The suggested analysis is demonstrated to be practically important for understanding of stress state in the mid and lower crust and might be applied to all the high resolution data of collocated electromagnetic and seismic experiments.

Y. Takei, Effect of pore geometry on $V_p/V_s$: From equilibrium geometry to crack. J. Geophys. Res. 107 (2002): 10.1029/2001JB000522.