

Transport and Microstructural Properties of Sand-Clay Mixtures

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To support the development of a code for joint inversion of electrical and seismic geophysical data we have performed a series of laboratory experiments on saturated sand-clay mixtures. Measurements include frequency-dependent electrical properties using the four-electrode technique (10 mHz to 1 Mhz), permeability, porosity, and acoustic velocities. We mixed clean Ottawa (quartz) sand with Wyoming bentonite in a number of different configurations containing 0 to 10 % clay: as a dispersed mixture, as discrete clay clusters and arranged in distinct layers. Solutions of CaCl₂ ranging from 0.0005 N to 0.75 N (0.05 to 64 mS/cm) and deionized water were used as saturating fluids.

We found the electrical properties to be dependent on clay content, fluid conductivity, and microstructure in a complex fashion. In general, increasing fluid conductivity and increasing clay content resulted in higher electrical conductivity. For an individual sample there were two main regions of conduction: one where surface conduction was dominant and another where the ionic strength of the saturating fluid controlled conduction. The sample geometry (dispersed, non-dispersed or layered clay configuration) was found to greatly affect the magnitude of the surface conductance in the low conductivity fluid range. We found that clay arranged in a layered structure provided a much higher surface conductance than for instance the dispersed arrangement.

Using electrical conductivity data and the measured parameters of permeability and porosity we were able to calculate formation factors, surface conduction terms, and lambda parameters for the various samples. The different sample geometries may provide bounds on the expected bulk conductivity of sandy soils and indicate an apparent specific surface area of the sand-clay mixtures. Current characterization of the samples using x-ray computed tomography will permit evaluation of sample alteration with time as the clay reacts to the saline solutions and organic solvents.

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