Archie's Law in Sandy Microstructures

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Abstract

COMSOL Multiphysics® is used to directly simulate electric currents in pore-level Sandstone sub-volumes of the McMurray formation as the primary source of oil in the Athabasca oil sands; the second largest oil reserve in the world. The numerical workflows are applied to the pore space geometries of thousands of grains, covering a broad range of porosity and grain arrangements, to investigate the effects of geometrical parameters on the effective electrical conductivity of pore-level oil sands facies. The image dilation technique is used to gradually enlarge the boundaries of regions of grains mimicking the cementation process. A pixel-wised pore morphological approach is then utilized to predict two-phase fluid occupancy profiles and conduct a detailed study of the electrical conductivity in partially saturated microstructures at low capillary numbers. The post-processing results present the ad hoc parameters of Archie's law including formation factor, cementation and saturation exponents, and tortuosity factor for each rock type. The effective electrical conductivities are analyzed and compared with EMT theoretical approach. The variations of the conductivity reveal the impacts of cementation, rock configuration, and saturation on the flow of electric charges and petrophysical description of granular consolidated and unconsolidated sandy microstructures.

Figures used in the abstract

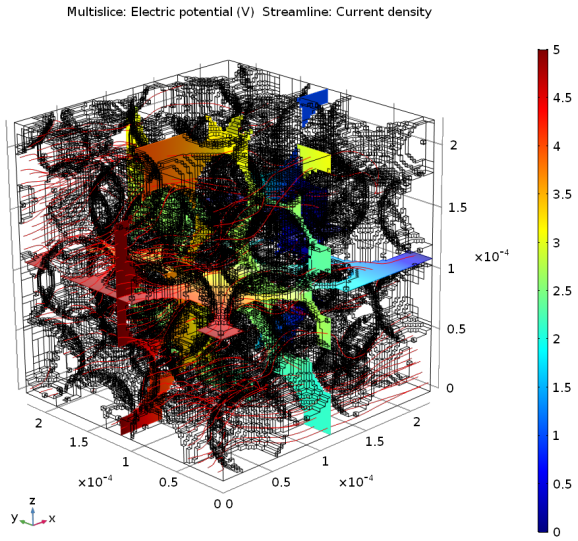

Figure 1: Electric potential distribution throughout a sandy microstructure used to predict the effective conductivity of the medium