MODELING PETROPHYSICAL PROPERTIES OF CARBONATE ROCKS USING DIGITAL ROCKS PHYSICS

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ABSTRACT

Macroscopic geophysical measurements are governed by petrophysical rock properties, therefore understanding the pore-scale structures of rocks is necessary to fully interpret large scale geophysical observations. Current geophysical interpretations rely on empirical models (for example, the application of Archie's law in electrical resistivity measurements) that attempt to link geophysical observables with geological properties of interest. However, the true petrophysical relationships are not fully understood. A physics-based model can help unlock the mysteries of pore-scale rock properties and interactions between fluid and rock. This can be achieved using digital rock physics, a methodology that performs numerical simulations of physical processes on a digital microstructure to estimate rock properties. Due to advances in imaging and computing capabilities within the last two decades, research in digital rock physics has significantly increased. The objective of this research is to enhance our understanding of the link between the pore-scale structures of rocks and large scale electrical geophysical observations. The focus of this study is to simulate the spectral induced polarization (SIP) and nuclear magnetic resonance (NMR) geophysical responses using reconstructed 3D rock structures from high-resolution X-ray microtomography (micro-CT). Carbonate rock samples with varying lithofacies and pore structures from the Cambro-Ordovician Arbuckle Group in Kansas will be used for micro-CT imaging. Reconstructed 3D rock structures from the micro-CT images will be used as the initial models. The numerical simulation of complex conductivity responses in saturated samples will account for the influence of the electrical double layer (EDL) by discretizing the rock volume into solid and fluid phases and assigning an appropriate complex conductivity value to each cell. The simulated results will then be compared with laboratory measurements. By performing forward modeling simulations on rock microstructures, this research will lead to a detailed physical understanding of petrophysical properties and processes such as electrical conductivity and fluid flow in carbonate rocks, and ultimately, to improved geophysical interpretation in the field.

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