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Computational Rock Physics: Imaging and Process Modeling at the Pore Scale

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Rock physics, and geosciences in general, has undergone a massive shift from descriptions of rocks and earth systems to include also process modeling, simulation, and process visualization. The fundamental aim of rock physics is to discover, understand and model relations between remotely-sensed geophysical observables and in-situ rock properties. Digital rock physics, using computation and high resolution imaging, has rapidly emerged as a potential source of rock property relations (elastic, flow, electrical, etc.) and fundamental understanding of pore-scale processes governing these properties. This talk will focus on examples of advances in imaging and computation in rocks at the pore and grain scale. Pore scale microstructure provides the underpinning of geological processes specially those involving fluid flow and transport in the earth's crust. Pore microstructure also impacts the geophysical response of the rocks, through their elastic and electrical properties. A key challenge in computational property estimation of rocks is the need to image the actual structure and topology of the pore space at different scales. The computational challenge is then to use the imaged complex microstructure to compute various properties, and simulate processes. The talk will show how a confluence of modern imaging technologies from physics, biology, medicine, and material science, when applied to rocks has started to yield massive micro- and nano-structural data about the pore geometry. Examples of different imaging techniques include confocal scanning laser microscopy (CSLM), scanning acoustic microscopy (SAM), micro- and nano-CT scans, acoustic force microscopy (AFM) and focused ion beam imaging (FIB). Advances in computing have led to algorithms that can handle the complex pore geometry without oversimplification (Keehm et al., 2001). Further, these computational tools allow us to interrogate microscopic (pore-scale) distributions of structural and mechanical heterogeneities, which often have significant effect on macroscopic properties (Sain et al., 2014). The improved understanding of such micro-scale heterogeneities aids in refining conventional theoretical models by accounting for more complex, realistic, and heterogeneous features of porous media.

References:

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