

Upscaling of Heterogeneous Rock Properties Via a Multiscale Image to Simulation Approach

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Abstract

The mass and recoverability of oil and gas in unconventional reservoirs strongly depend on the understanding the petrophysical properties of the rocks at a large range of scales. Three-dimensional imaging is capable of unveiling the detailed microstructures within the rocks down to the nanometer scale. Using a multiscale imaging protocol, a Devonian shale rock sample with heterogeneities is digitized at different resolutions. After determination of a representative elementary volume (REV), Figure 1, finite element meshes are created from 3D imaging data. Darcy and Stokes-Brinkman models from COMSOL Multiphysics are employed using a novel upscaling framework [1,2], Figure 2. This approach features modeling of local transport properties (permeability for example), which are upscaled to independent imaging results at lower resolution, instead of overlapping fine scale meshes with and coarse scale in the same spatial domain. Verification and validation of the results are discussed. The image to simulation diagram (Figure 3) supported by Avizo® and COMSOL Multiphysics allows detailed analysis and modeling of microstructures. It presents a unique opportunity to obtain insights of the material properties of materials including but not limited to shale rock.

Reference

Reference

1. M. Pal. "A New Approach to Simulation and Upscaling of Single-Phase Flow Through Vuggy Carbonates". Proceedings of the COMSOL Conference 2009, Milan, Italy, Oct 14th-16th, 2009.
2. S. Zhang, Robert E. Klimentidis, & Patrick Barthelemy. "Micron to millimeter upscale of shale rock properties based on 3D imaging and modeling ". Society of Core Analysis 2012 Meeting, paper A080, Aberdeen, UK, August 26th - 31st, 2012.

Figures used in the abstract

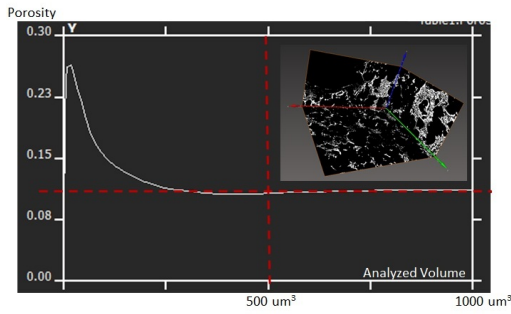


Figure 1. Selection of representative elementary volume. The inlay figure shows the segmentation of pore microstructure from the 3D imaging data. The horizontal line shows the porosity of the volume. The vertical lines shows the size of minimum REV.

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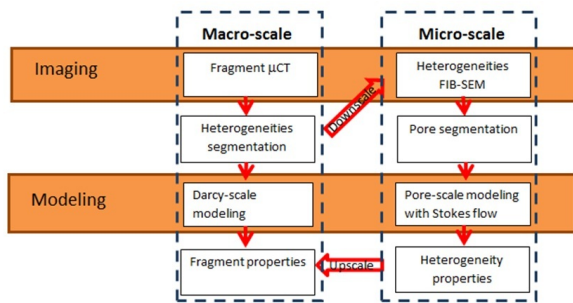


Figure 2. Multi-scale imaging and modeling diagram.

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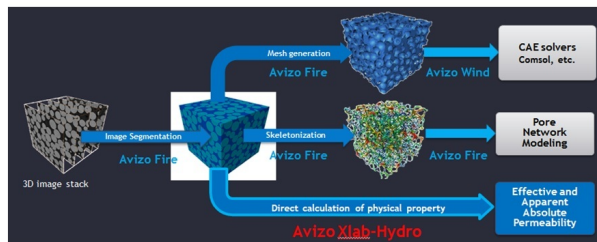


Figure 3. Image to simulation workflow for digital rock physics.

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