Permeability Anisotropy in Barnett Gas Shale

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ABSTRACT

Core permeability experiments are routinely used in reservoir-scale matrix characterization. Therefore, understanding permeability heterogeneity in cores is crucial. We conducted pulse-transient decay (PTD) permeability tests on layer-parallel cores samples of Barnett Shale and observed two timescales of dissipation: 1) rapid (~10's of minutes) equalization in pressure between the upstream and downstream pressure sensors; and 2) a slow (~10's of hours) decrease in pressure of both upstream and downstream sensors towards a final equilibrium value. We constructed a layered dual-permeability model composed of alternating high and low permeability material to simulate the observed dual-timescale behavior. Thin (~8 mm) thick low permeability (~1.4 nD) layers interbedded with high permeability layers (~240 nD) and ~6 mm layer spacing reproduce the observed pressure behavior. X-ray micro-computed tomography and thin sections independently confirm this layered architecture corresponding to variations in matrix fabric (clay/organic matter content). The dual-permeability layered model explains the observed Barnett matrix permeability anisotropy ratio ($k_H/k_V = 40$). A better understanding of core-scale heterogeneity can help illuminate gas flow at the reservoir scale.

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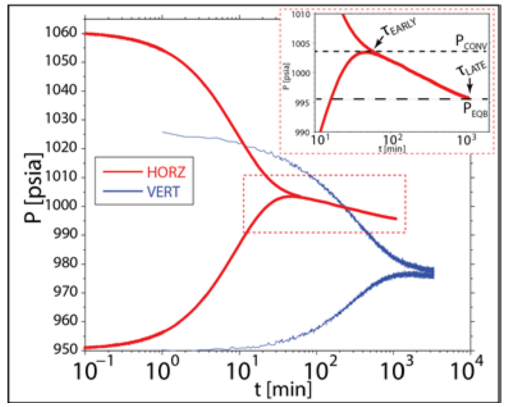


Fig. 1: Pulse-transient decay (PTD) data for horizontal (red) and vertical (blue) core. Horizontal core displays dual-timescale response, an early reservoir pressure convergence timescale and a late-time pressure dissipation timescale.

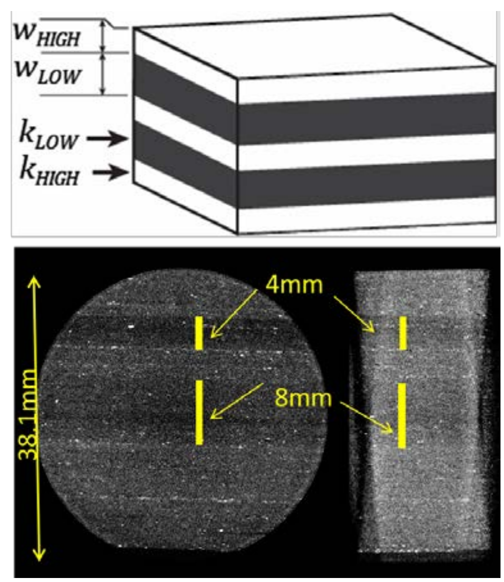
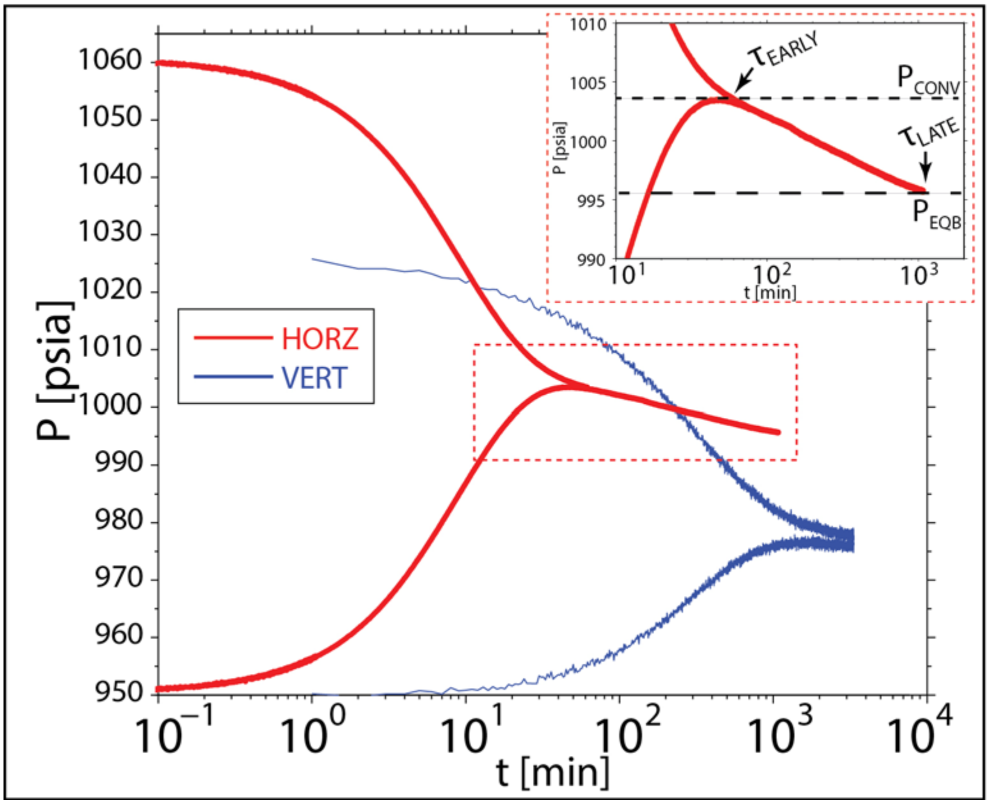


Fig. 2: Top: Layered dual-permeability model. Bottom: Micro-CT scan of Barnett core sample reveals mm-scale stratigraphic layering.



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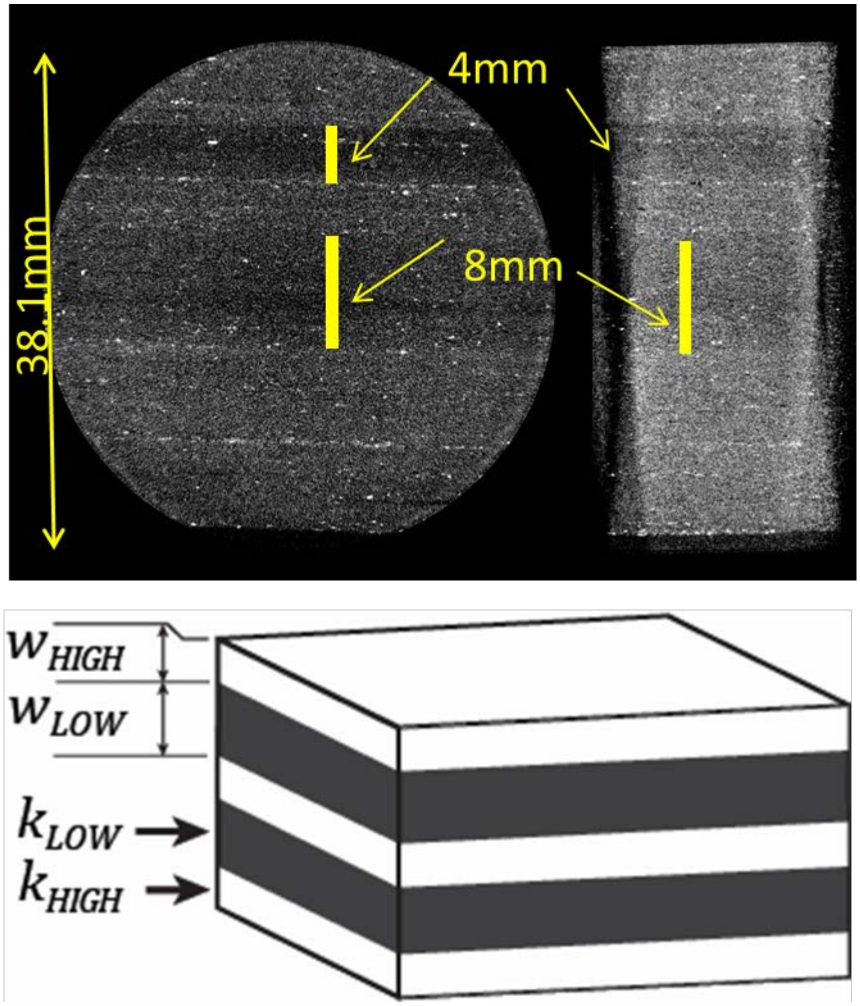
Back



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Back