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Fundamental Study of Disposition and Release of Methane in Shale Gas Reservoirs

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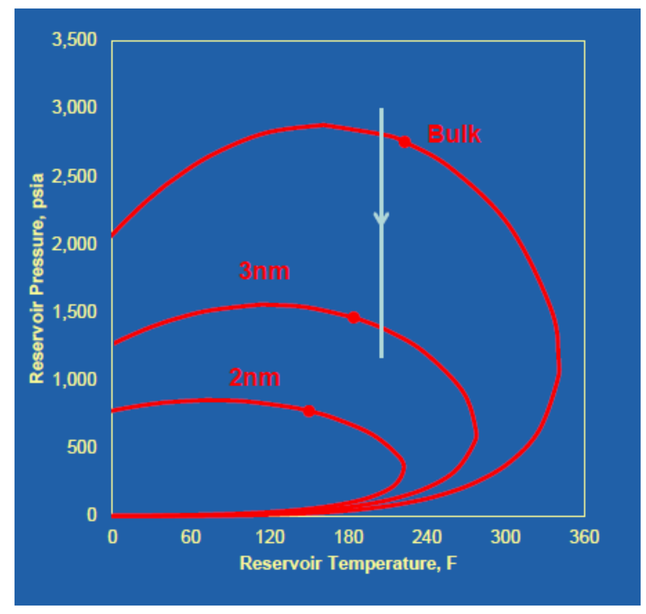
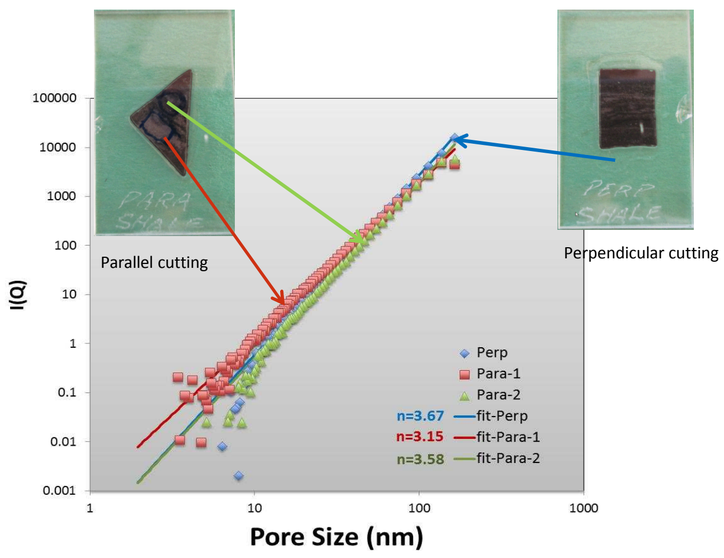
Objective

Use an integrated experimental and modeling study to fundamentally understand methane partitioning in the nanopores of mudstone matrices and methane transport from low-permeability matrices to hydrofracking-induced fracture networks.

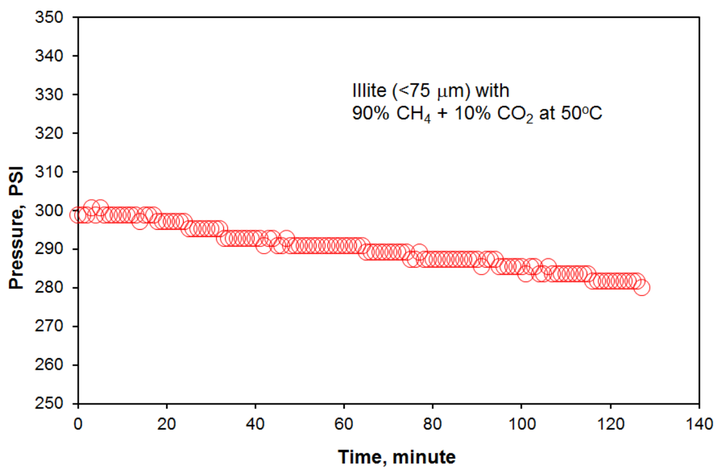
Problem Statement

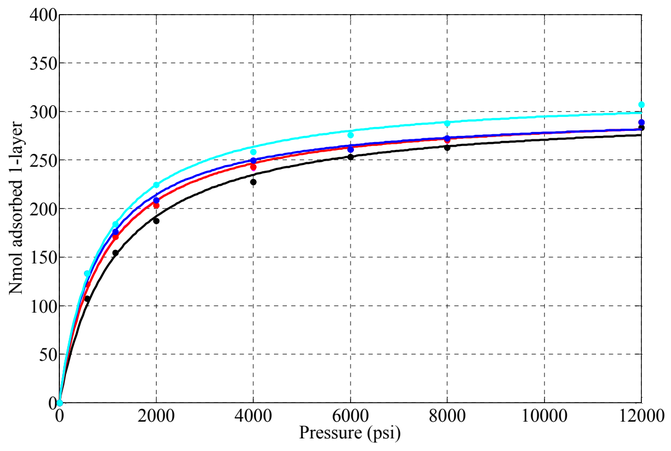
- Sustainability of shale gas production:
  - Large variability and unexpected rapid decline in well production (up 95% reduction over first 3 years)
  - Low recovery rates (<10%)
  - New well to be drill to maintain the supply
  - $9 M/well; $42 B/year in US; increasing cost/well
  - Little known about secondary gas recovery in "brown fields" (>90% of total gas reserve!!!)
- Maximizing individual well production is the key to realizing energy security benefits of shale gas
- Understanding methane disposition and release in shale gas reservoirs is crucial for developing engineering approach to maximizing wellbore production and extending the production cycle.





- The greater of n value, the smoother of particle surface
  n (clays): 2.5-3.3
  n (rock salt): 4
- Heterogeneity feature of the shale. SANS enable to measure specific area of intact sample





Technical Approach

- Based on novel concepts of nanogeochemistry and nanofluidics;
- Use state-of-the-art microanalysis techniques to characterize nano-sized pore networks in shale;
- Use unique high P/high T systems to determine methane sorption, desorption and transport behaviors in shale under reservoir-relevant conditions;
- Use molecular dynamic (MD) modeling to mechanistically understand methane interactions with mineral/kerogen substrates;
- Develop constitutive relationships for methane disposition and release using novel upscaling techniques.

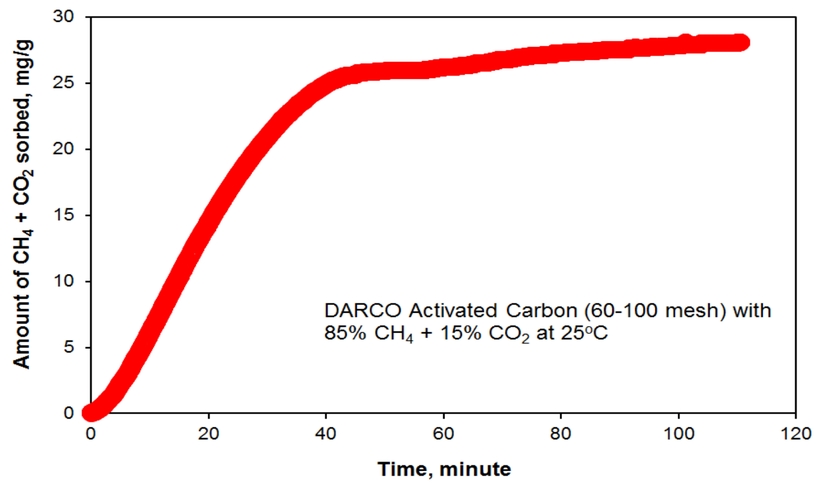


Table 1. Experimental measurements of sorption capacities and sorption rates for the model substances at 1 bar totol pressure

Model Substances	Temp, °C	Gas Mixture, volume percent	Pressure, bar	Sorption Capacity, mg/g	Sorption Rate, mg/g min^{-1}
DARCO activated carbon	25	85% CH_4 + 15% CO_2	1	28	0.68
	50	85% CH_4 + 15% CO_2	1	11	0.59
	75	85% CH_4 + 15% CO_2	1	9.0	0.31
	100	85% CH_4 + 15% CO_2	1	2.1	0.14
	125	85% CH_4 + 15% CO_2	1	1.8	0.10
Montmorillonite, <75 μm	25	85% CH_4 + 15% CO_2	1	2.8	4.7×10^{-2}
	50	85% CH_4 + 15% CO_2	1	0.30	9.6×10^{-3}
	75	85% CH_4 + 15% CO_2	1	0.19	6.7×10^{-3}
	100	85% CH_4 + 15% CO_2	1	0.18	5.1×10^{-3}
	125	85% CH_4 + 15% CO_2	1	0.12	3.3×10^{-3}

Potential Impacts

- Significantly advance fundamental understanding of hydrocarbon storage, release, and flow in shale,
- Provide more accurate predictions of gas-in-place and gas mobility in reservoirs.
- Help to develop *new stimulation strategies to enable efficient resource recovery from fewer and less environmentally impactful wells*.
- Provide the basic data set to test the concept of using supercritical CO_2 as an alternative fracturing fluid for simultaneous methane extraction and CO_2 sequestration.

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