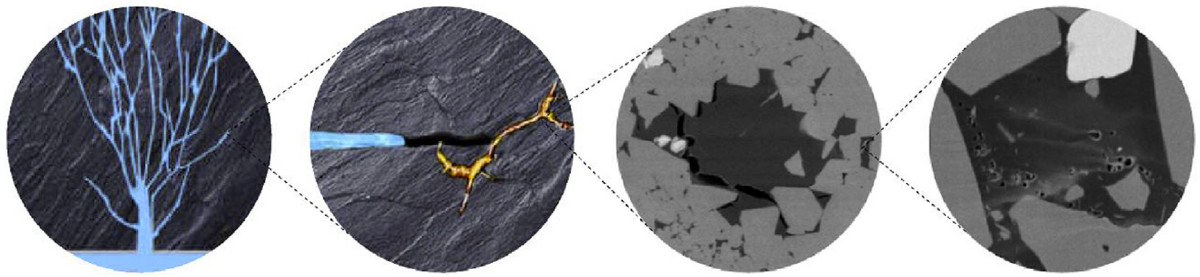
Molecular Signatures of Enhanced Oil Recovery in Shale Organic Pores

Felipe Perez† and Deepak Devegowda
†*felipe.perez@ou.edu*

The UNIVERSITY *of* OKLAHOMA
Mewbourne School of Petroleum and Geological Engineering

1. Background

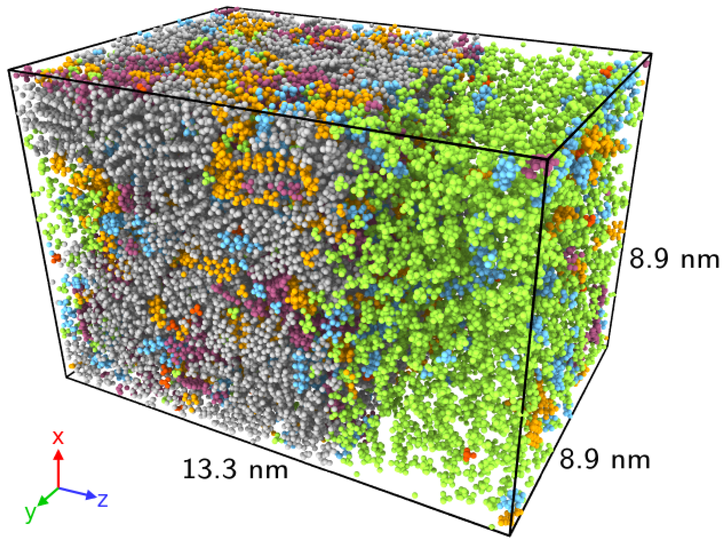
- Oil and natural gas are mainly stored in pores in organic matter in shale rocks.
- The size of the organic pores in shales ranges from a few to a couple hundred nanometers.
- Permeability of shale rocks is of the order of nanodarcies.
- Horizontal drilling and hydraulic fracturing have made oil and gas extraction possible in nanoporous shale plays.
- Hydrocarbon recovery from shale reservoirs is less than 10%.
- **Can we inject a solvent to extract more hydrocarbons?**



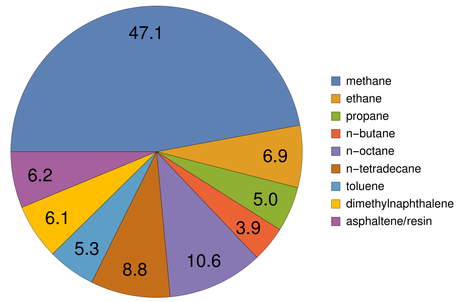
cm | mm to μm | μm to nm | nm

Modified from Ref. [1]

2. System: kerogen + black oil + microfracture + solvent



$T = 355$ K, $P = 214$ atm



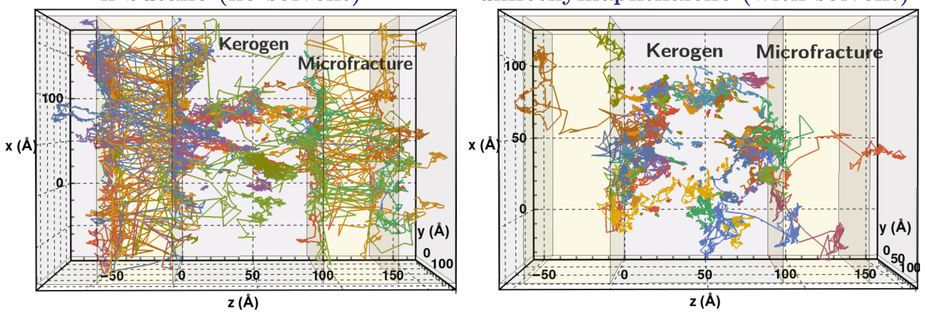
Black oil composition (mole fraction)

Color code:

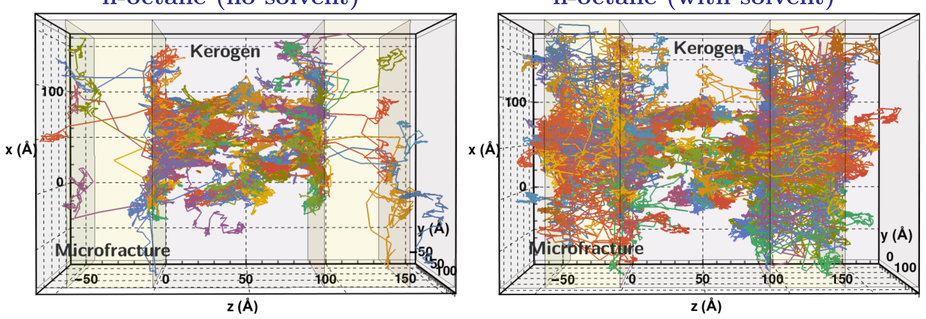
- Kerogen
- Asphaltene/resin
- Heavy and aromatic components
- Intermediate components
- Methane
- Solvent

3. Interaction with a solvent during soaking time

n-butane (no solvent) | dimethylnaphthalene (with solvent)

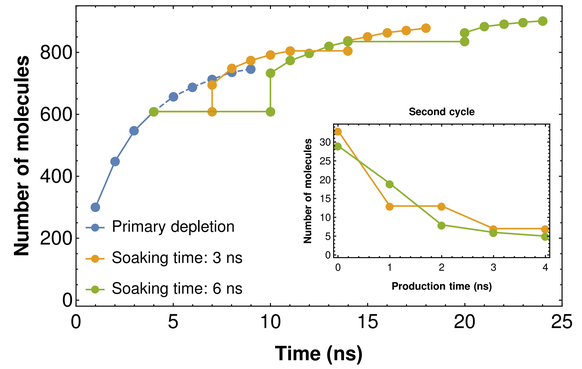


n-octane (no solvent) | n-octane (with solvent)



- Huff-and-puff (cyclical injection) steps:
  1. Inject fluid
  2. Soaking period
  3. Resume production
- n-butane molecules have a higher mobility in the absence of a solvent, thus they can be preferentially produced over n-octane at same conditions.
- n-octane molecules slide along the surface of kerogen and travel to the kerogen-microfracture interface to remain adsorbed there.
- The solvent enters the pores in kerogen and is able to desorb, extract and potentially recover molecules that could not be produced by primary depletion.
- Even in the presence of a solvent, dimethylnaphthalene remains adsorbed onto the organic pore surface.

4. Conclusions



- The use of solvents may enhance the recovery of species that could not be produced during primary depletion.
- Solvent efficiency is not the same for every hydrocarbon component. The design of an enhanced oil recovery project must take into account the type of molecules being targeted.

References

[1] Xianfu Huang and Ya-Pu Zhao. Characterization of pore structure, gas adsorption, and spontaneous imbibition in shale gas reservoirs. *Journal of Petroleum Science and Engineering*, 159:197–204, 2017.

Acknowledgments

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