U N I V E R S I T Y O F B E R G E N

Department of Physics and Technology

Oil Production from Tight Shale Using CO_2

Rognmo* A. U., Lysne M., Fredriksen S. B., Fernø M. A. and Graue A.

Department of Physics and Technology, University of Bergen, Norway

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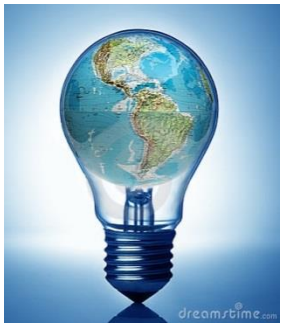
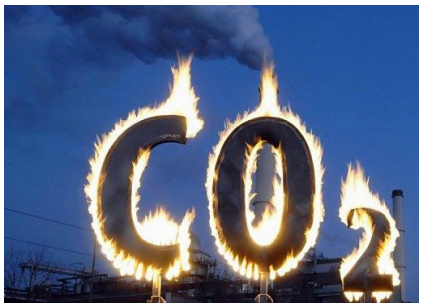
Outline

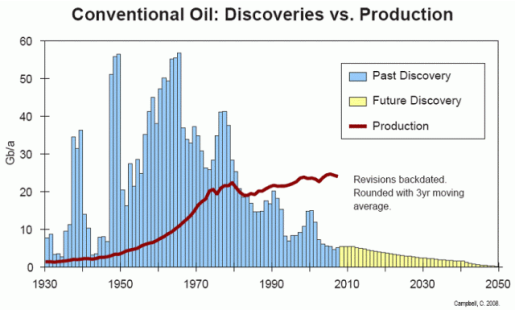
- Motivation
- Experimental setup
- Observations and results
- Concluding remarks

Key numbers

- 37%
- 76%
- 20%
- 6%
- 10 Mb/d



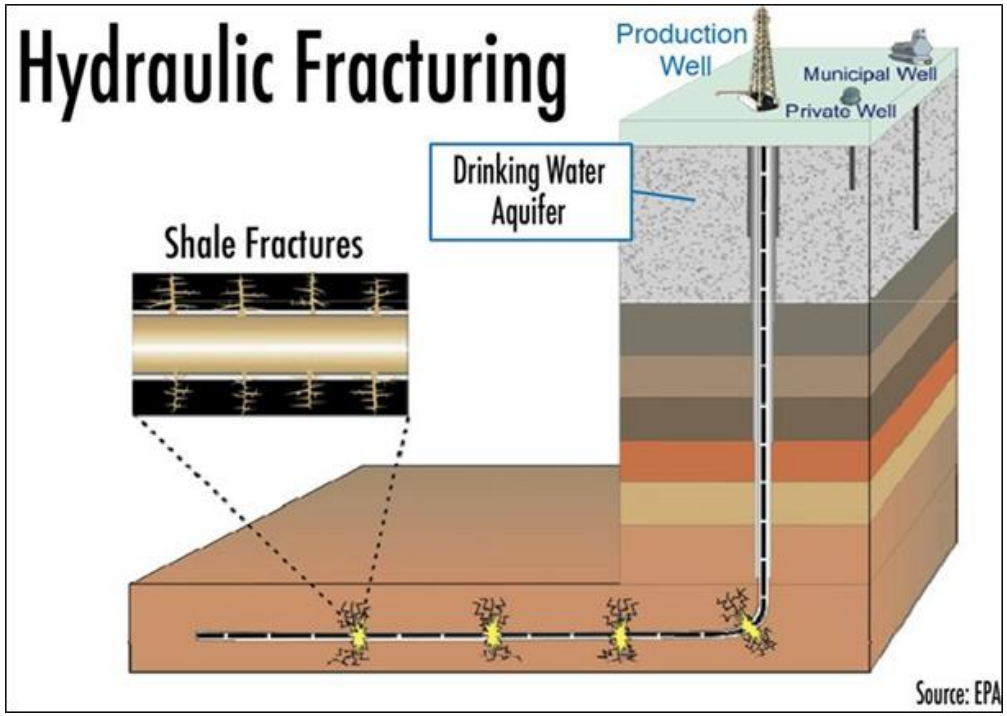




(EIA, 2011; DOE/EIA, 2014)

Oil production from shale-oil

- Hydraulic fracturing and horizontal drilling
- Low R_f ~ 3-10% of OOIP
- Estimated reserves in the US~24 billion barrels



(DOE/EIA, 2014; EPA, 2010; Liu *et al.*, 2014)

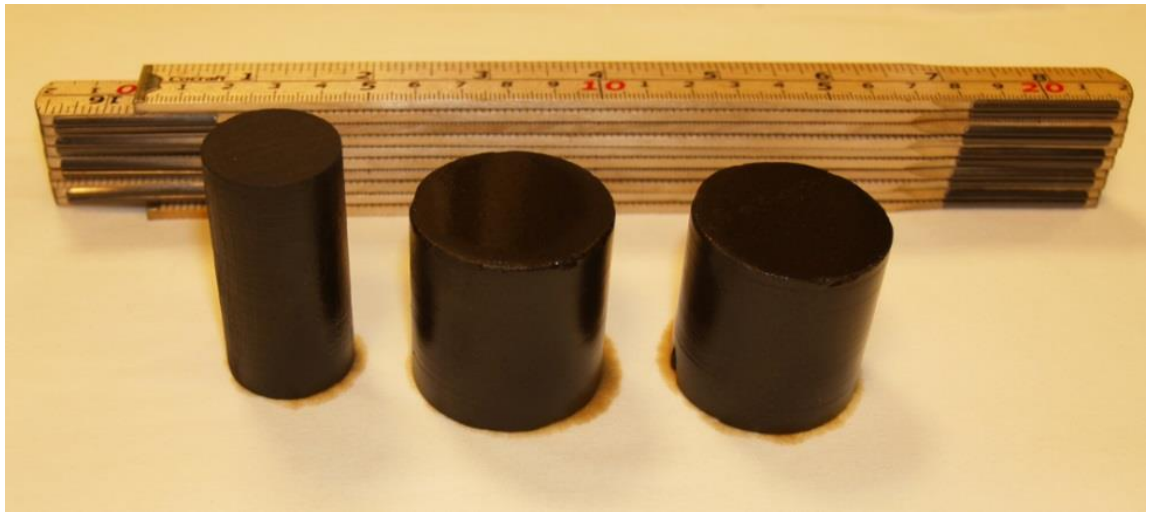
CO_2 for EOR in shale-oil formations

- Incentives (CCUS)
- Beneficial CO2 properties
  - Miscibility
  - Relative high density and viscosity
- Lower formation breakdown pressure and improved fracture network compared to water

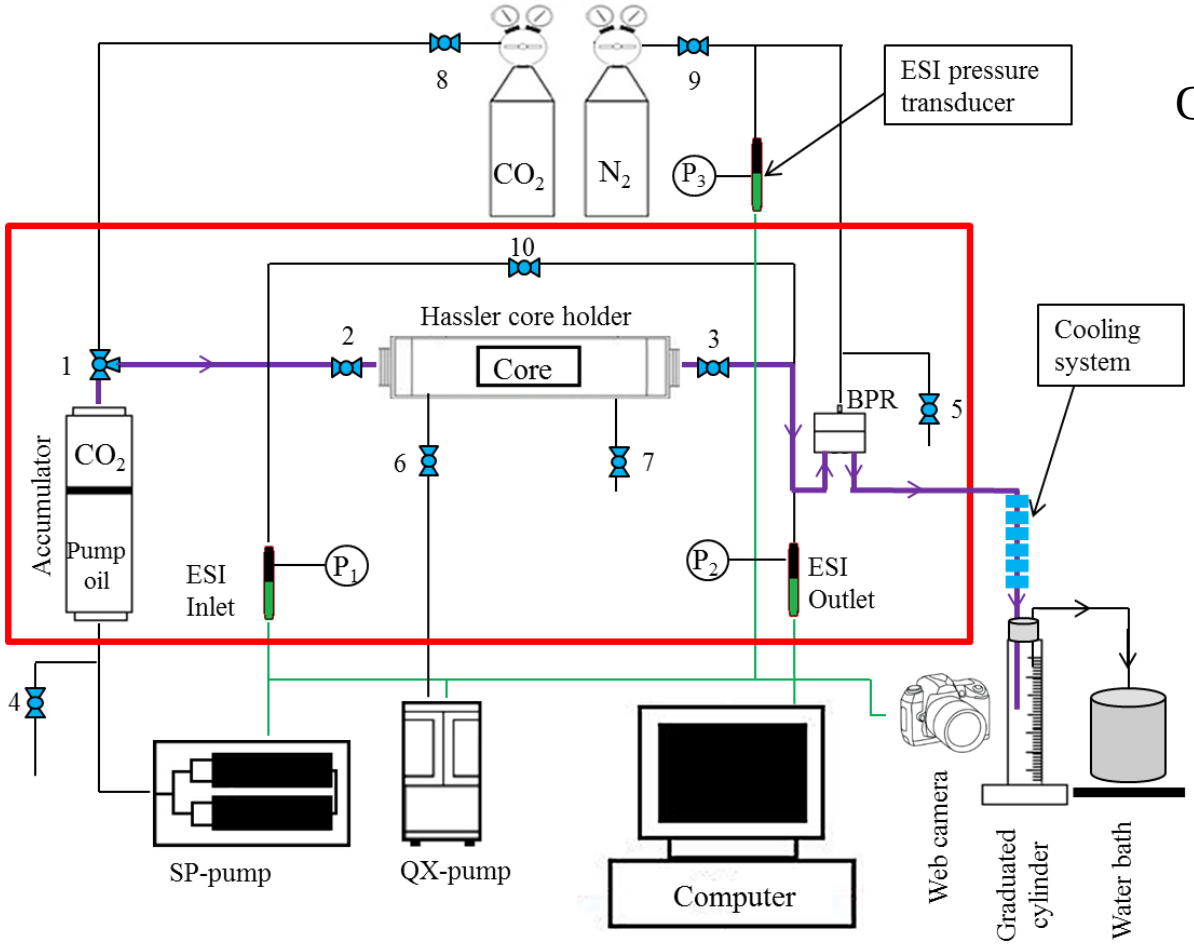
Experiments and results

Experimental overview

- 22 miscible CO_2-injection tests (shale-oil core plugs)
- 1” and 1.5” core plugs
- L ~ 1-2”
- K~ 60 nD – 3 μD
- φ ~4-9%



Experimental setup – CO_2-injection

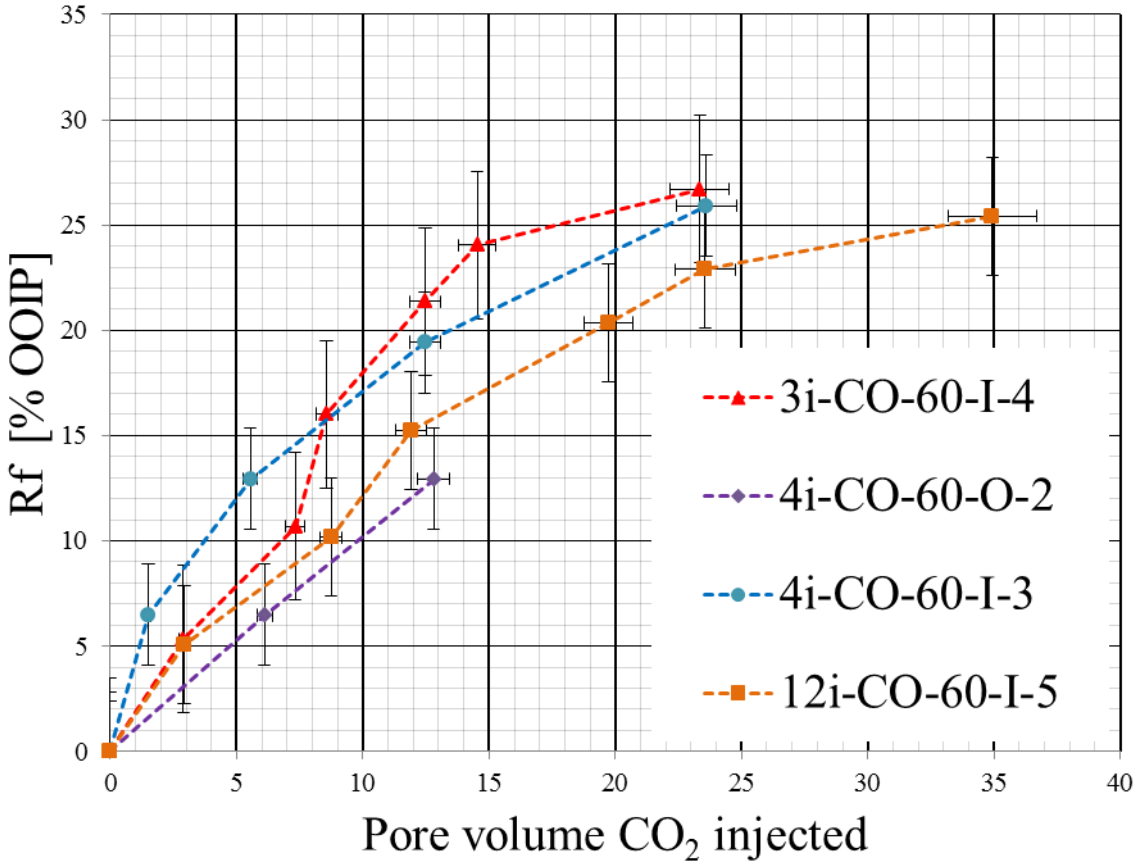


General experimental conditions:

- Inlet: 220 bar (3200 psi)
- Outlet: 150 bar (2200 psi)
- O.burden: 310 bar (4500 psi)
- 60ºC (140ºF)
- 3 hours – 8 days
- 0.2 – 60 PV CO_2 injected

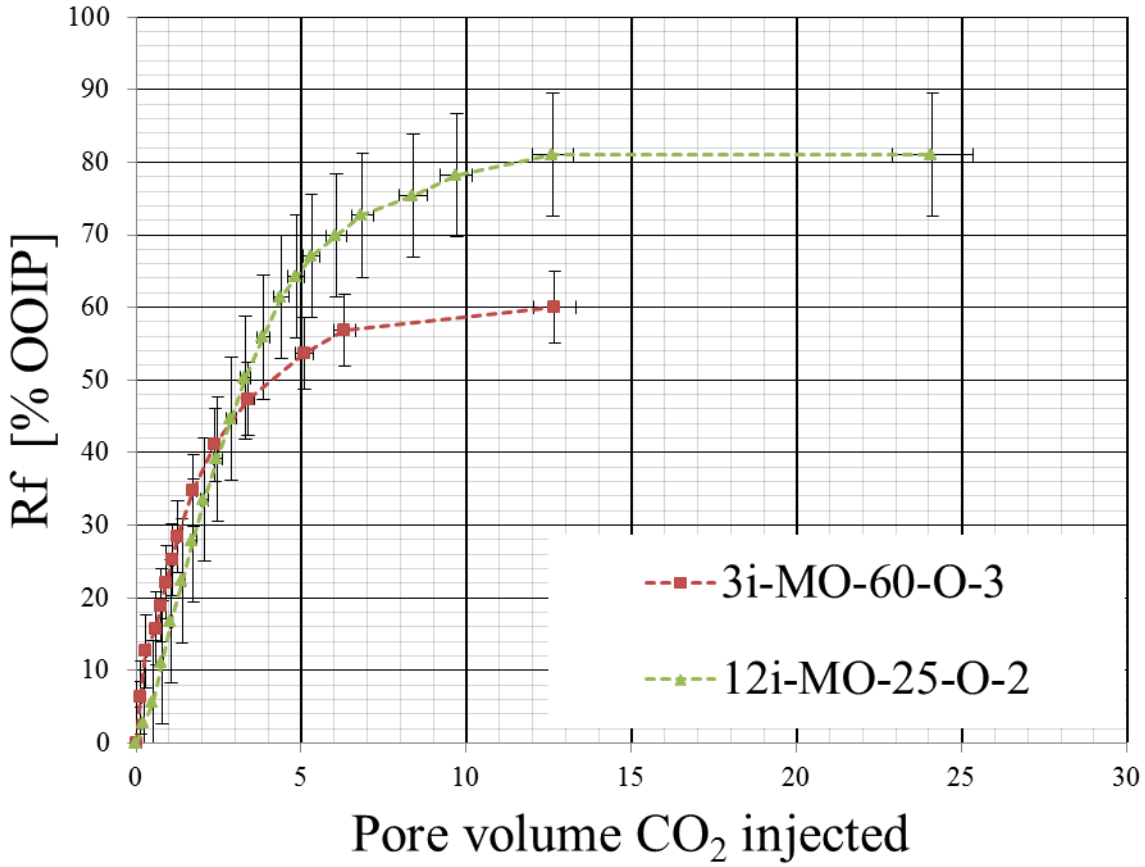
CO_2 EOR in shale-oil samples

Crude oil (multi-contact miscible)



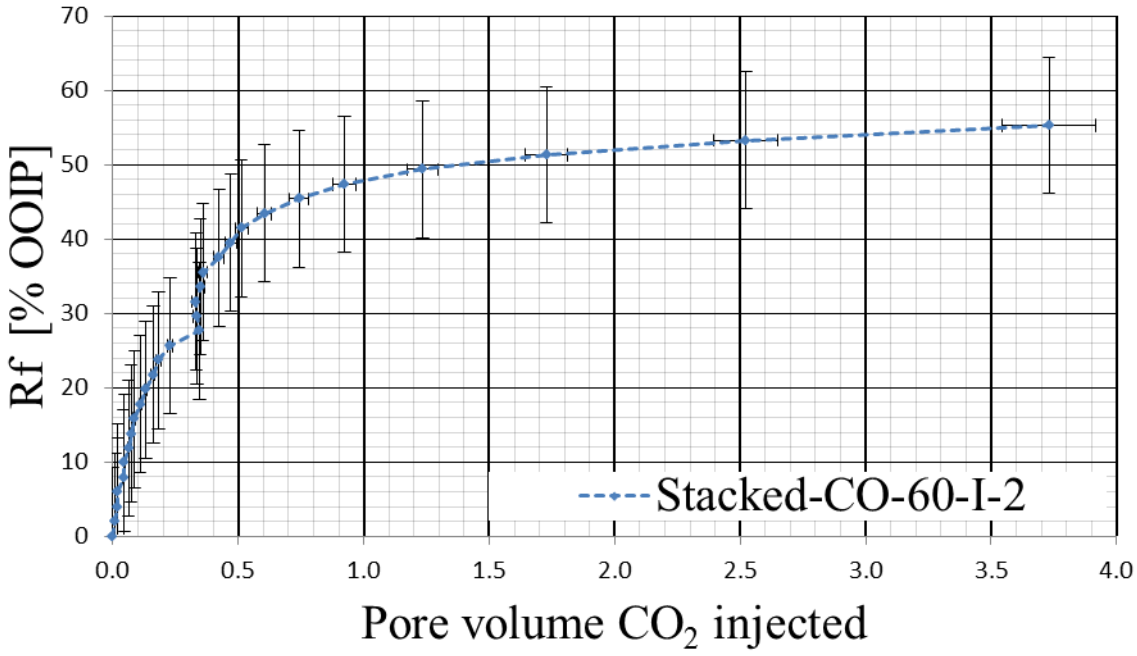
CO_2 EOR in shale-oil samples

Mineral oil (first-contact miscible)

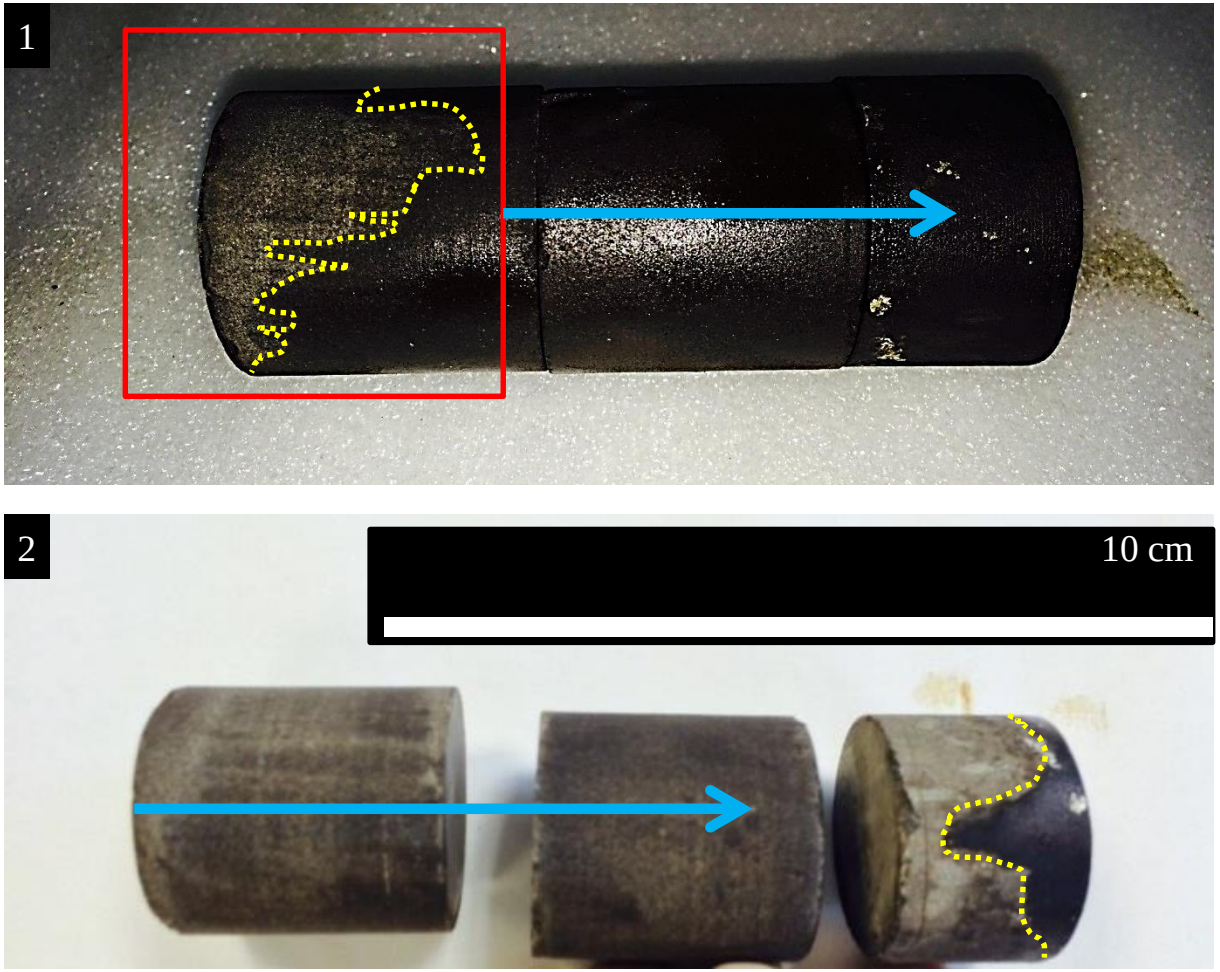


CO_2 EOR in shale-oil samples

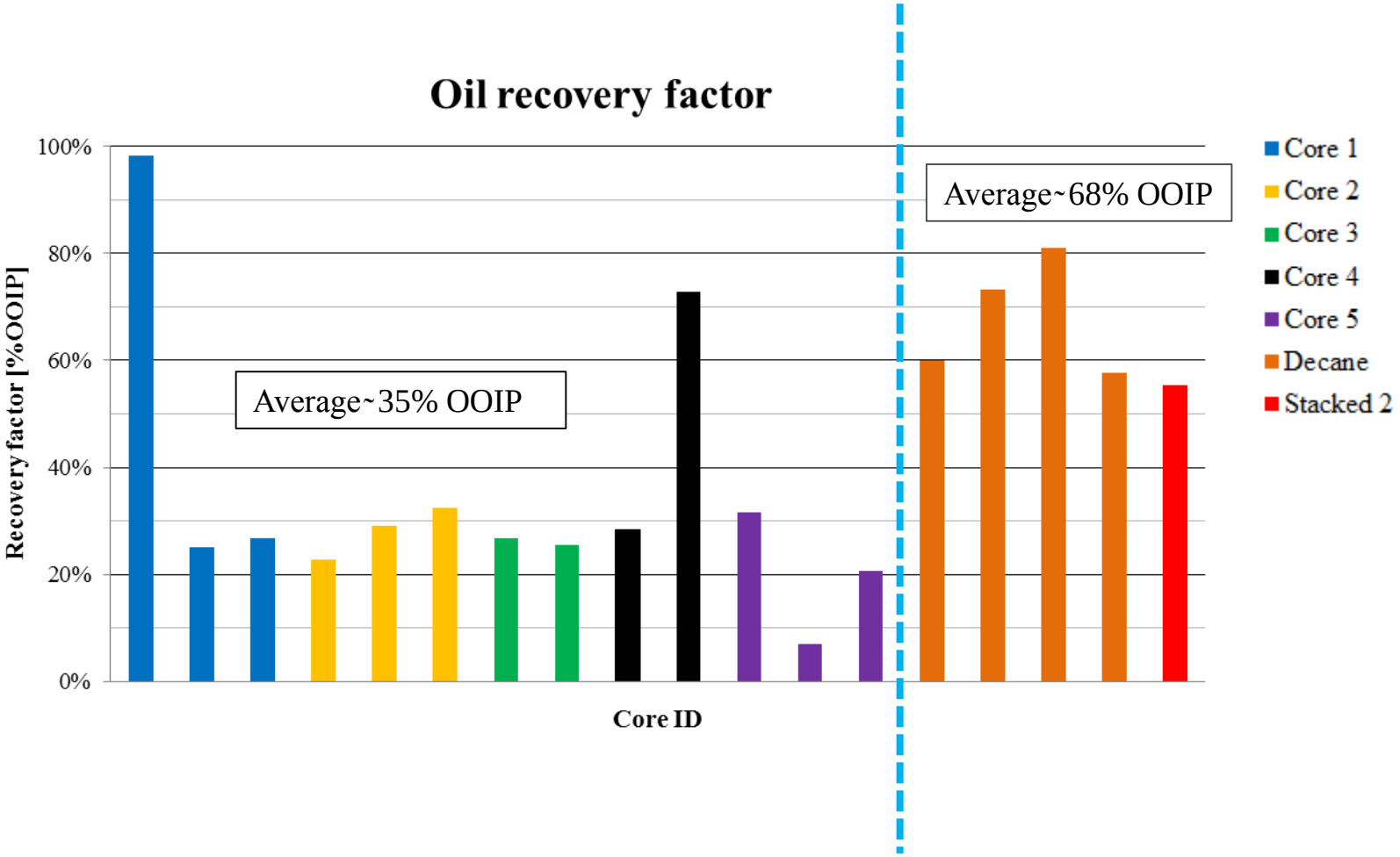
Increased length (multi-contact miscible)



Increased system length

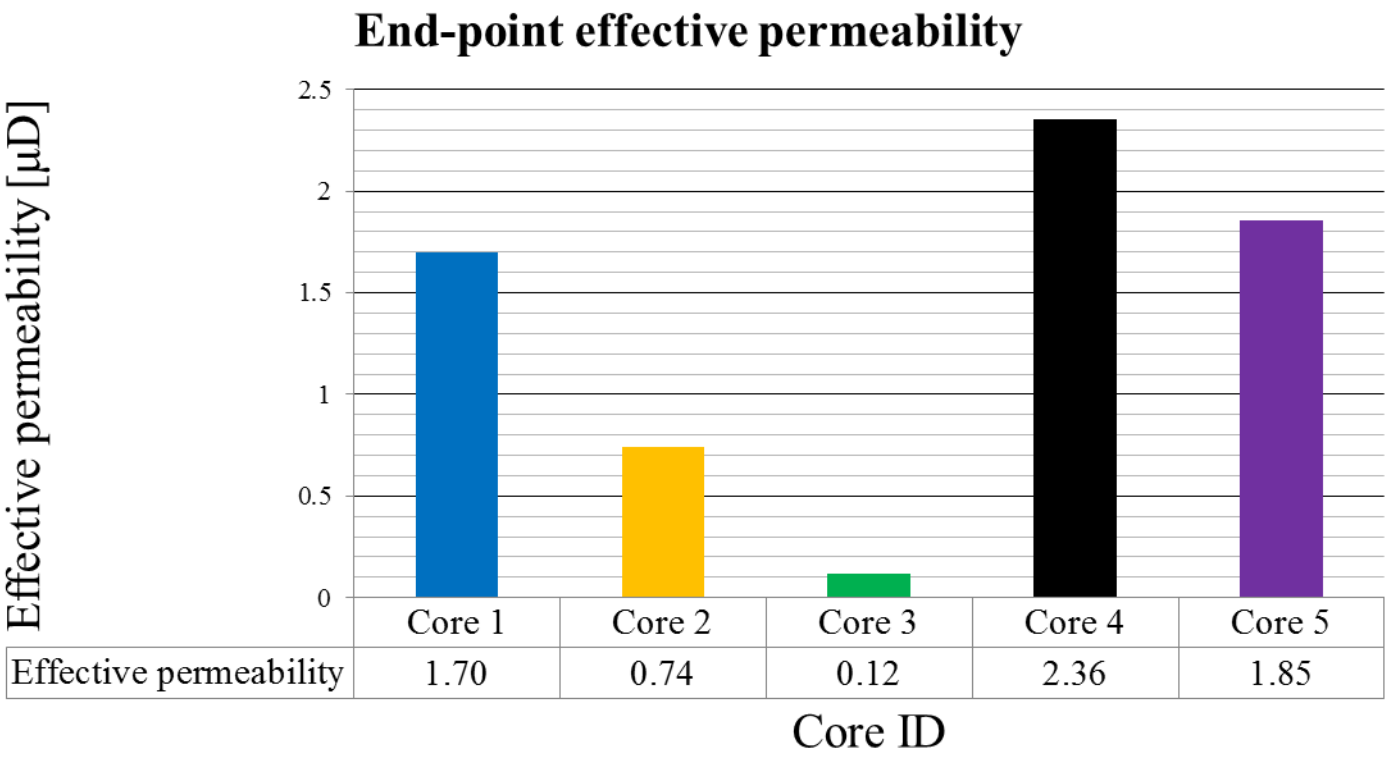


Oil recovery factor - overview

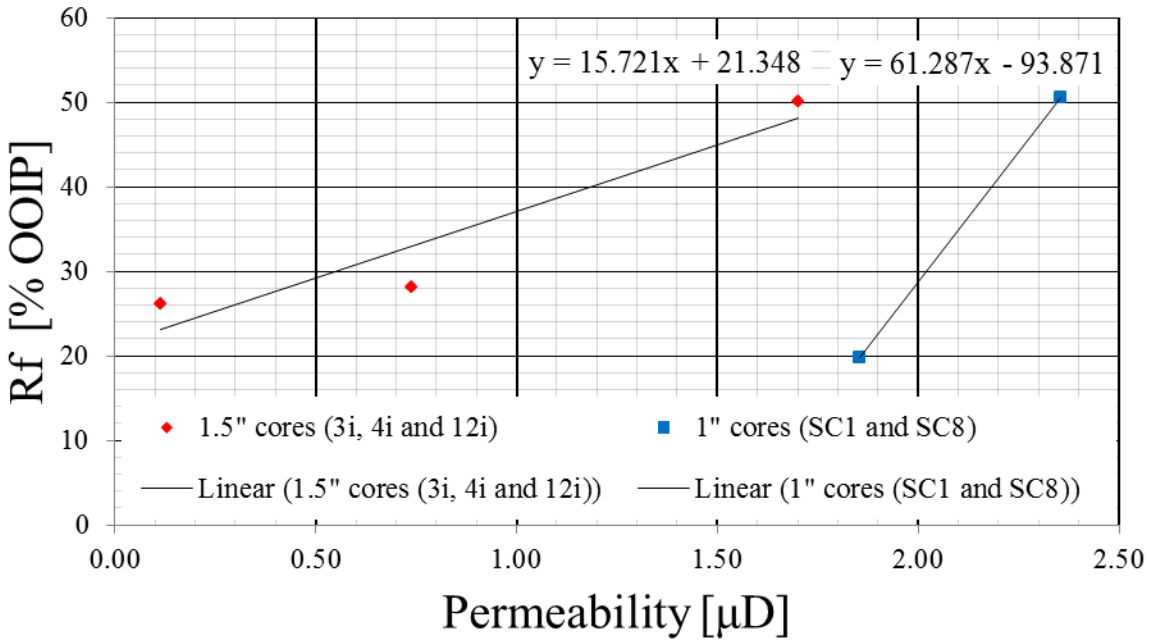


Fluid flow capacity

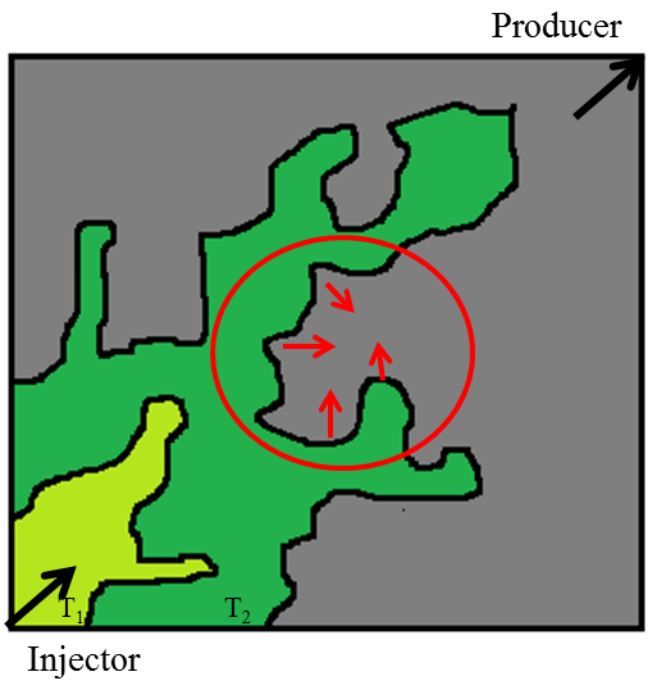
- End-point effective permeability
- $K`_{eff,CO_2} = -\frac{\mu_{CO_2}}{A}\frac{Q_{CO_2}L}{\Delta P}$

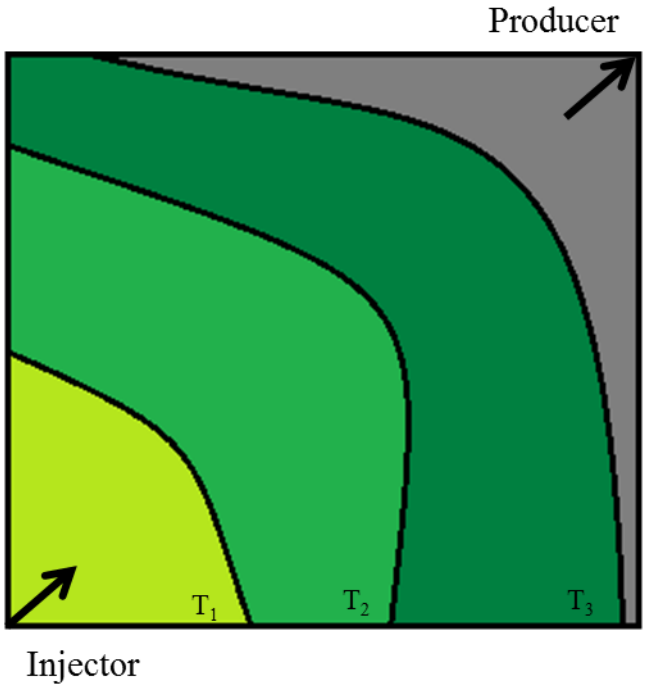


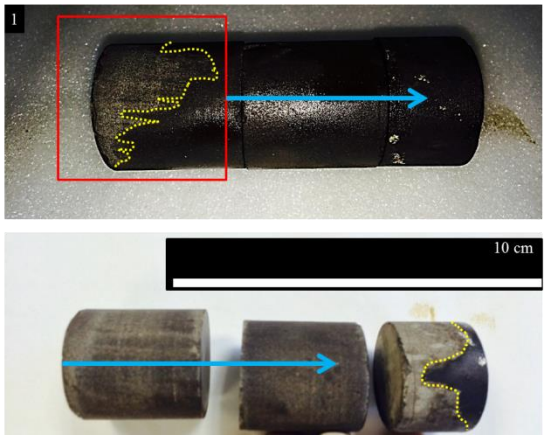
Effect of permeability on oil recovery



Improved sweep by diffusional forces







Conclusions

- Oil extraction from CO_2-injection without fracking the formation is possible in ultra-tight shale samples (59 nD – 2.36 μD).

- Average R_f for crude oil saturated cores yielded 34.9% of OOIP (19.8-50.5% of OOIP).

- Recovery of oil from tight shale-oil is strongly dependent on achieving miscibility between CO_2 and oil phase, corroborating the assumed importance of diffusive forces.

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