U N I V E R S I T E T E T I B E R G E N
Department of Physics and Technology

The Effect of Diffusion During CO_2 EOR in Fractured Reservoirs

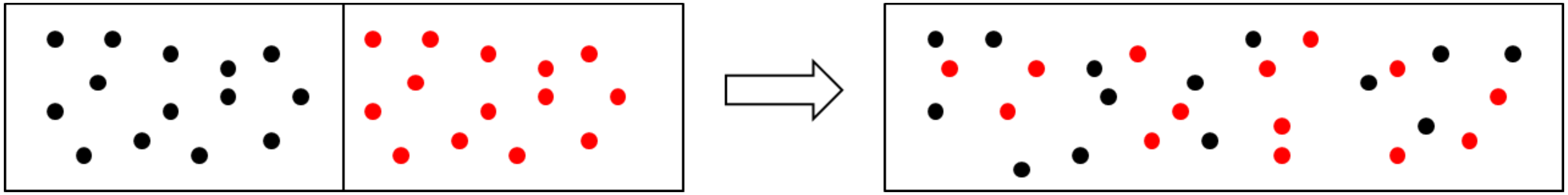
CO_2 for EOR as CCUS

November 21 2013

Øyvind Eide

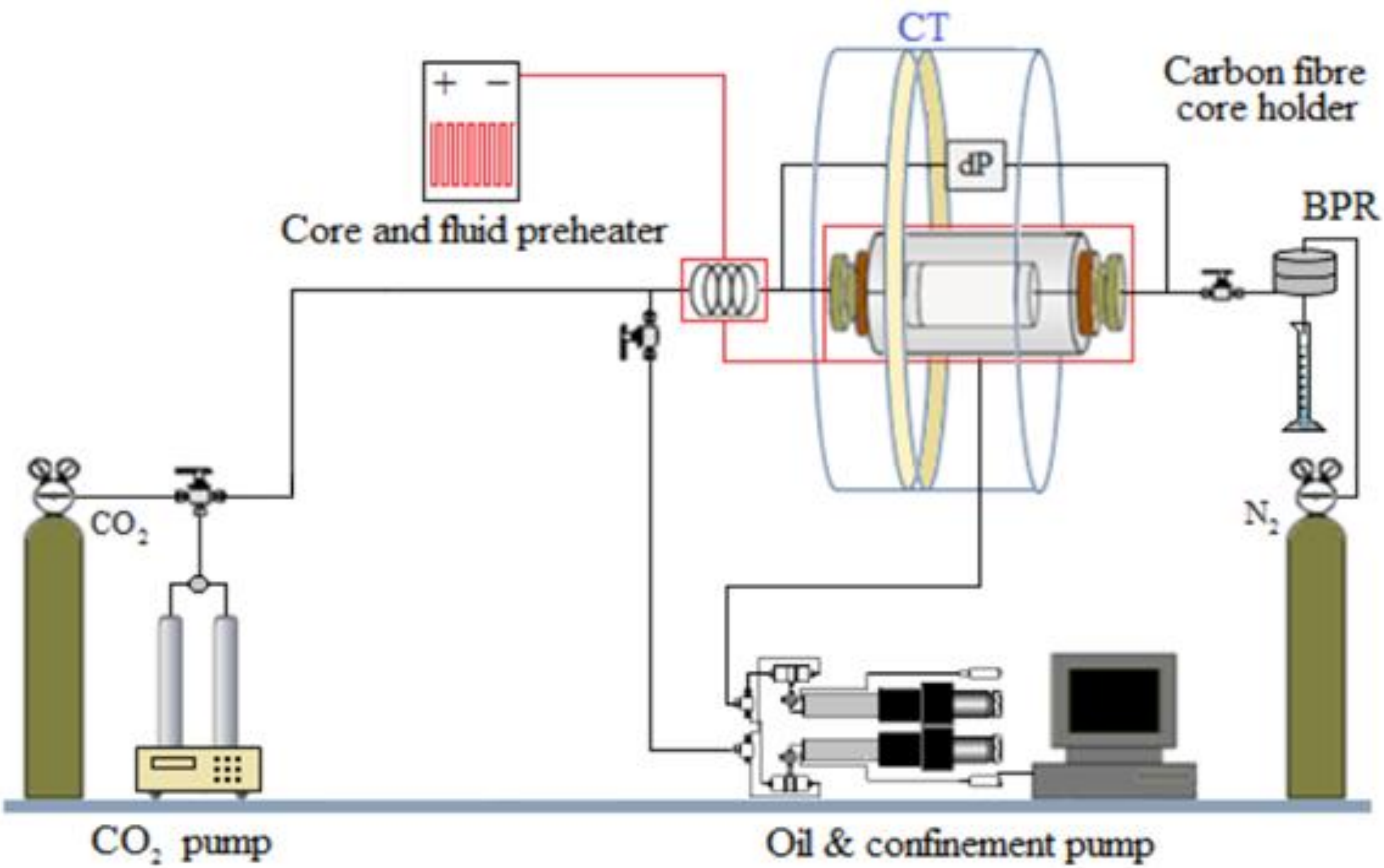
Introduction

- Calculate diffusion coefficients
  - Simple system
  - Analytical solution
- Demonstrate diffusion on laboratory scale
- Molecular diffusion



  - Saturation gradient dependent
  - Blocking of phases
  - Tortuosity
- Less important at large length scale – highly dependent on fracture density
- Volume expansion

Experimental Setup



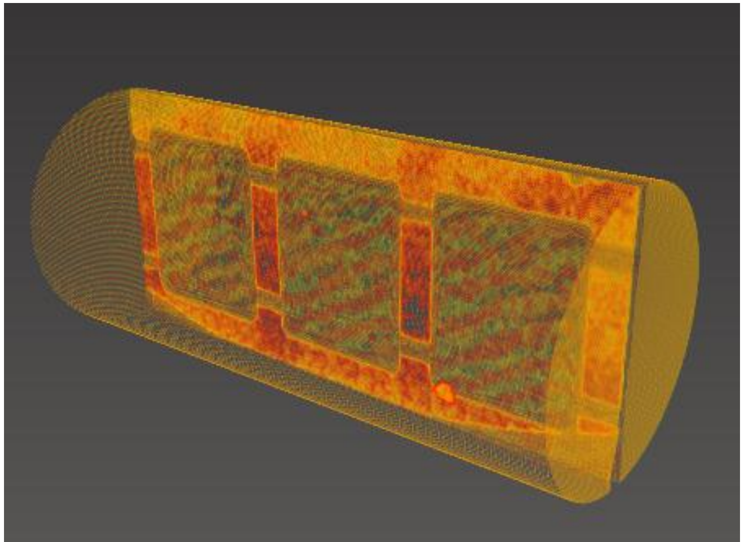
Experimental Setup

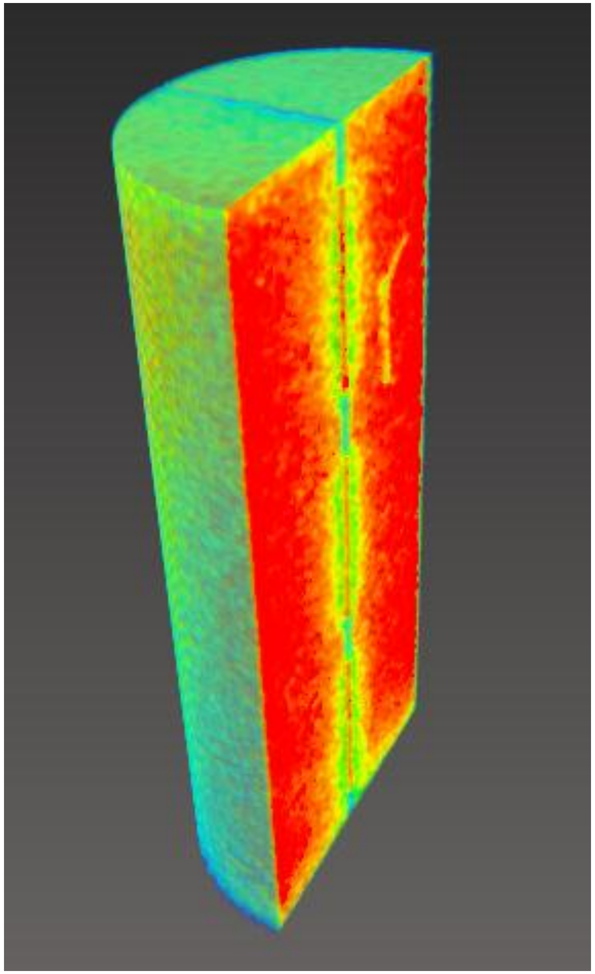
- Outcrop rock samples (strongly water-wet)
- Rørdal Chalk
- Standard core size (1.5” x 8 cm)
- No water present
- Open fracture (1 mm aperture)
- 100 bars pressure (~1500 psi), 42 °C (107 °F)
- Core mounted horizontally

Fluids	Contents	Density [g/cm3]	Viscosity [Pa·s]
CO_2	> 99.999 % CO_2	0.63756	48.876
n-Decane	$C_{10}H_{22}$	0.72228	760.92
1-Iodooctane	$C_8H_{17}I$	1.33	N/A

Experimental Setup

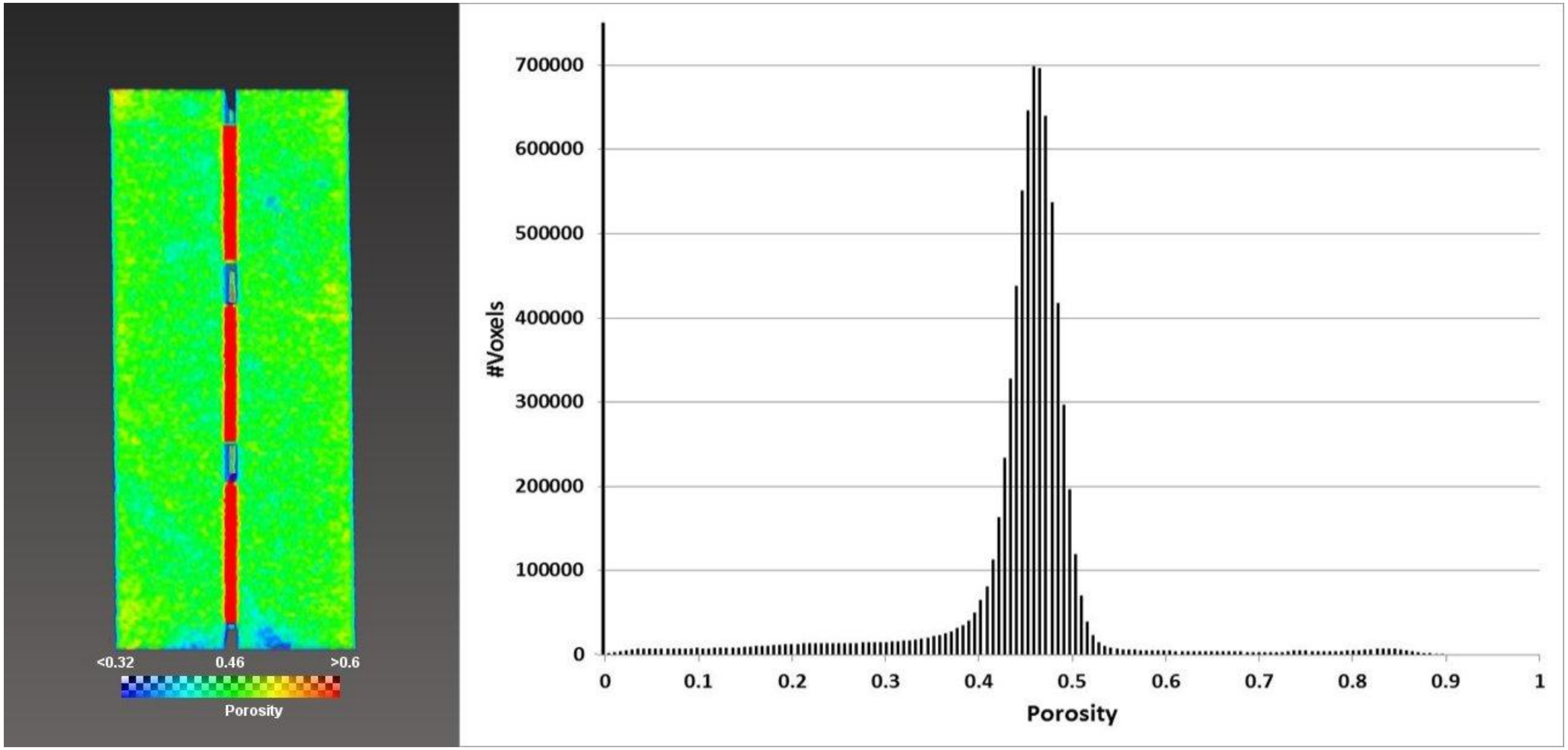
- Spacer
  - Create high perm flow path
- Reference scanning
  - At pressure and temperature
  - Provides explicit saturations
  - No water present
- Digital cut-out





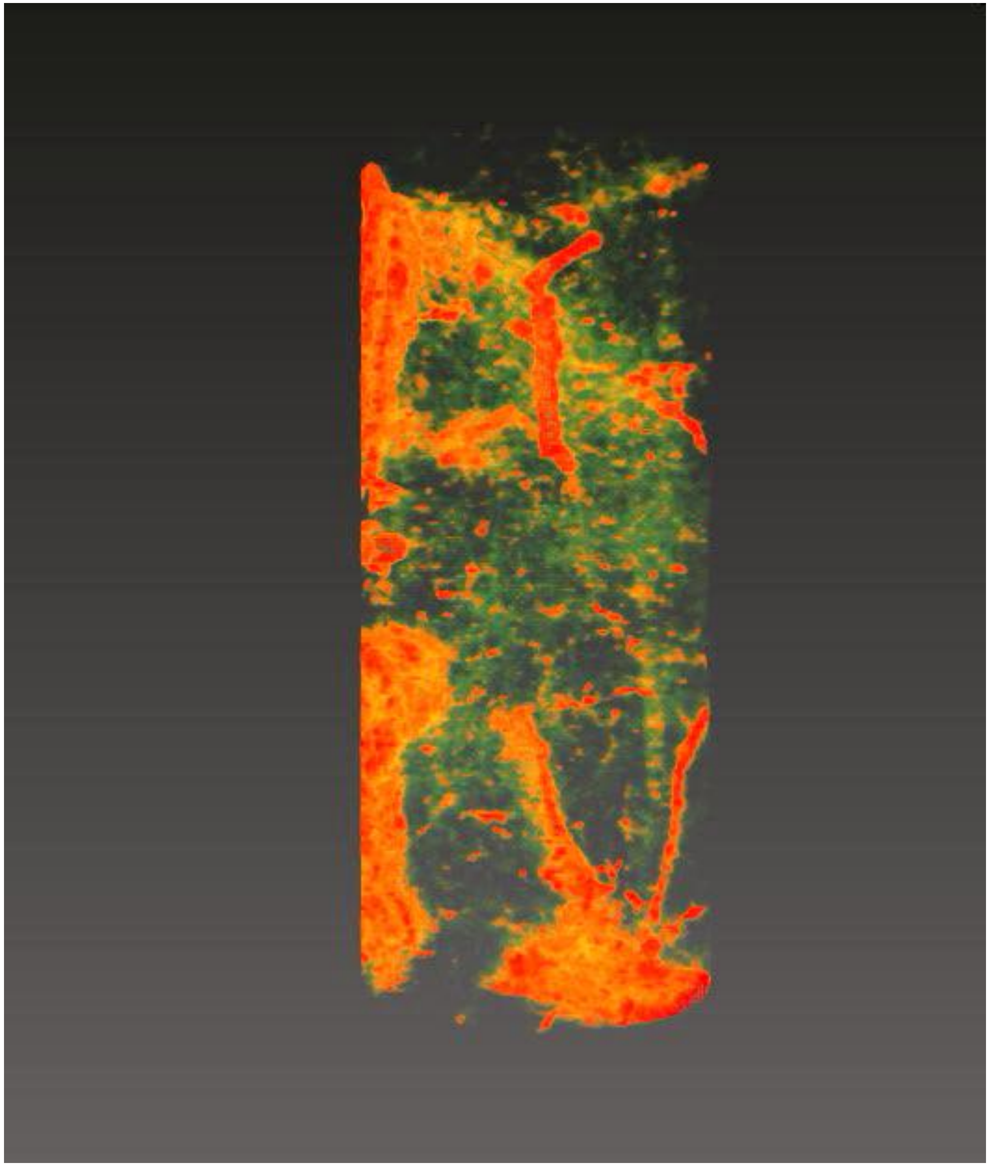
CO2 Injection

- Porosity map



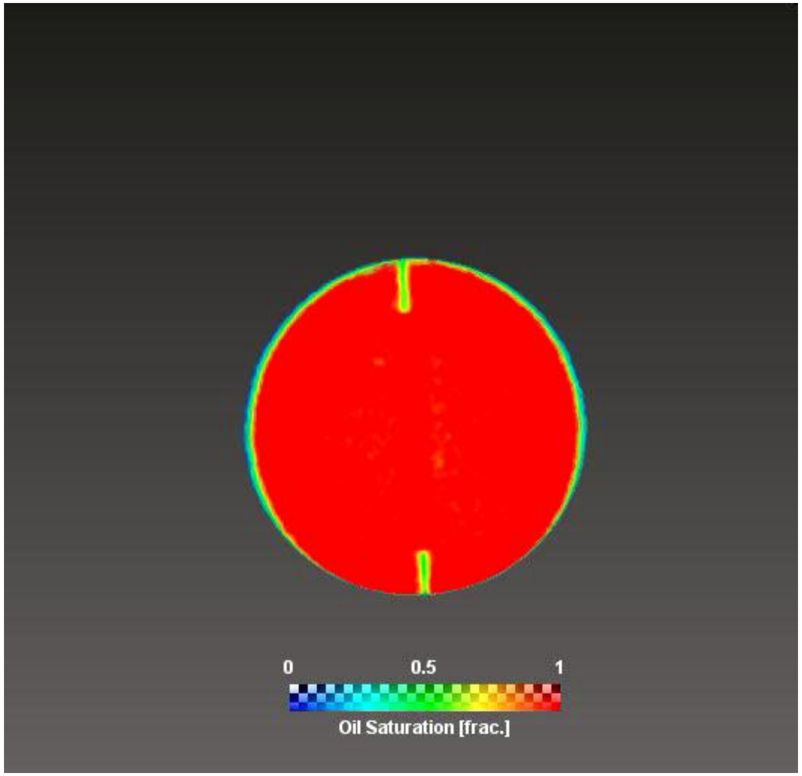
CO2 Injection

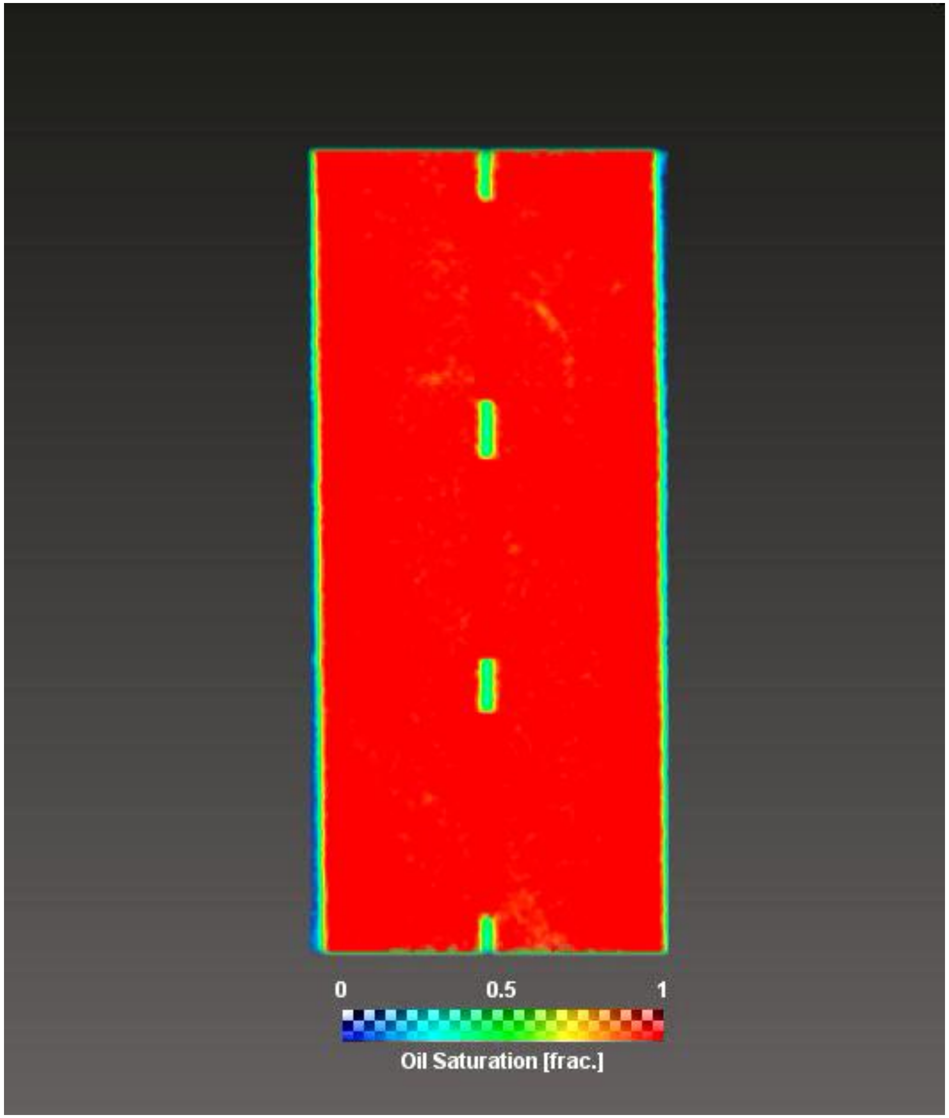
- Higher density areas
- Calcite filled burrows
- Symetrical around fracture



CO2 Injection

- Heterogeneities
- Gravity





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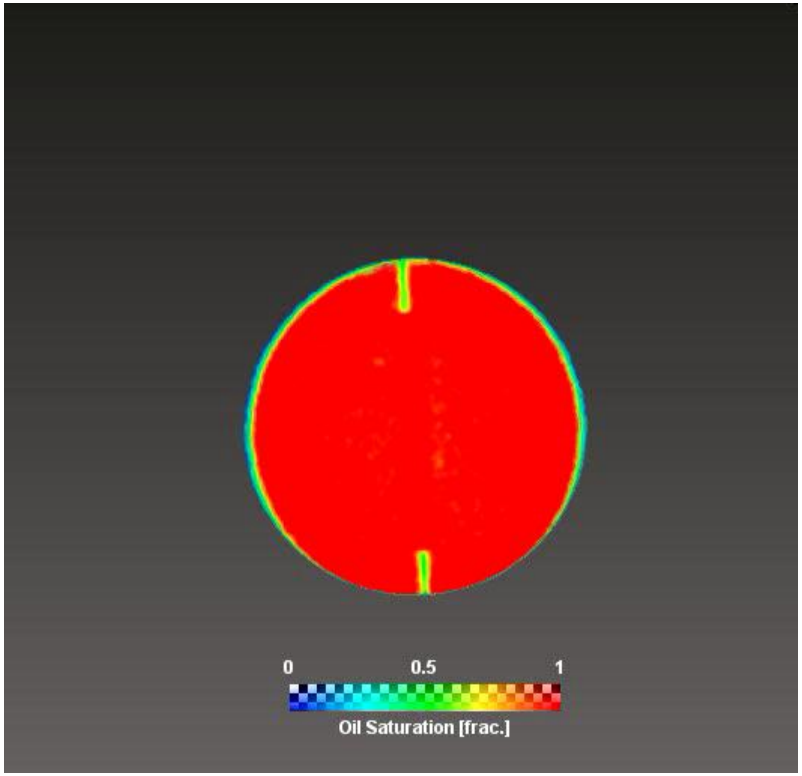
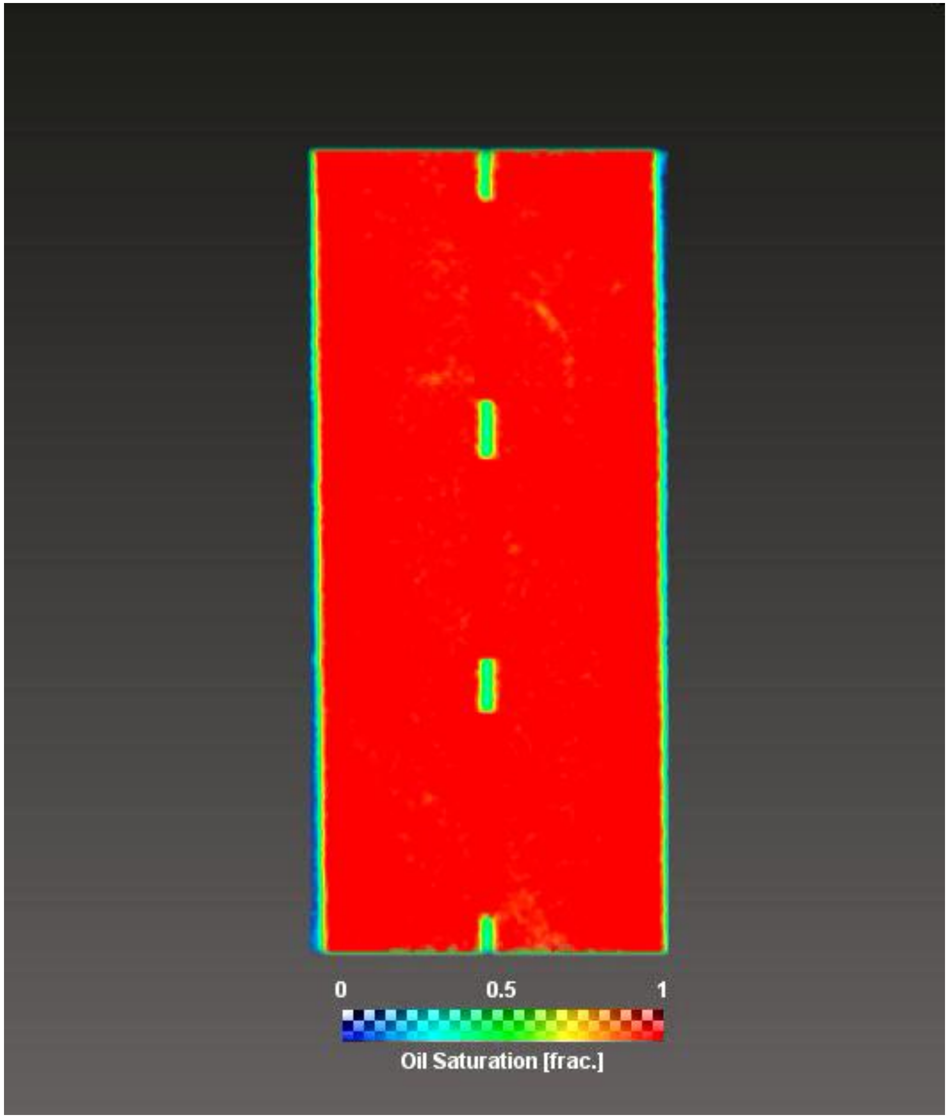
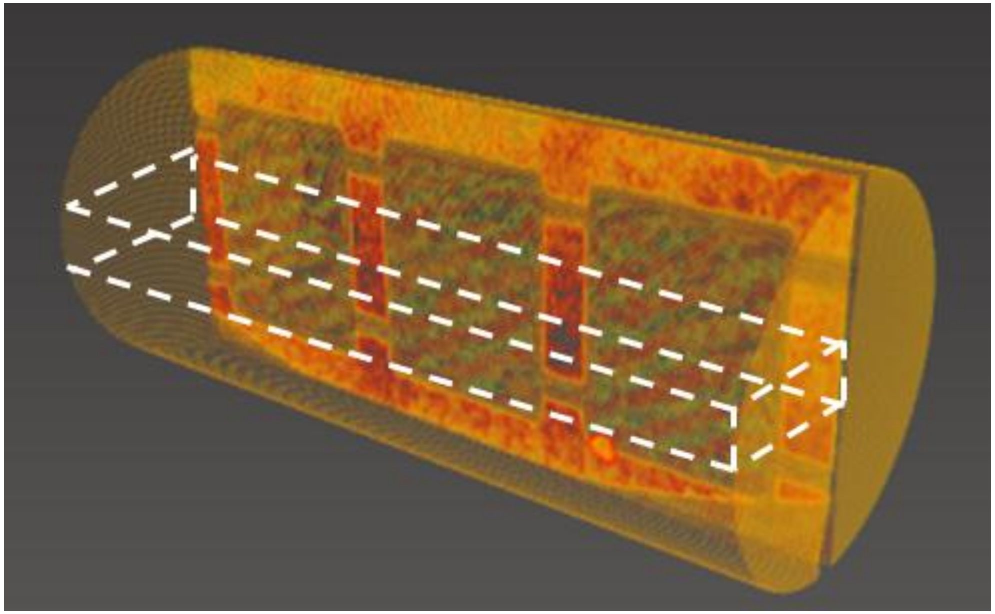




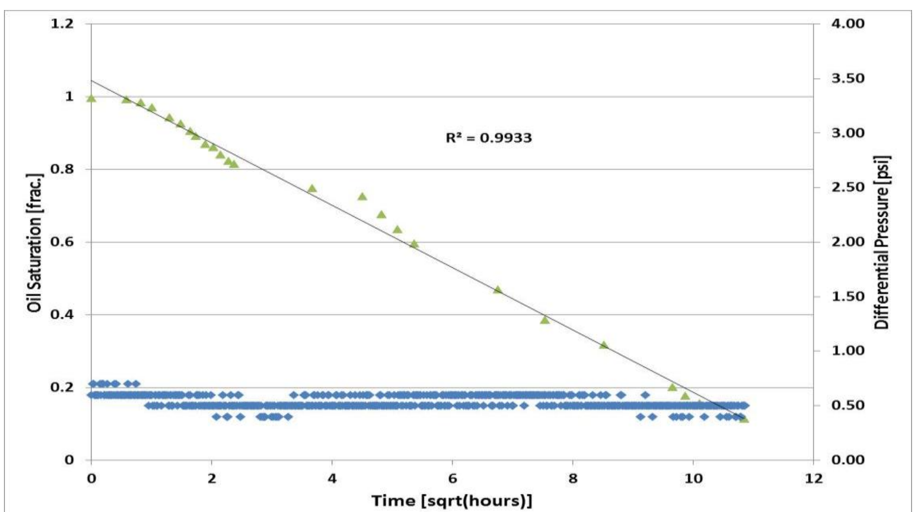
CO2 Injection

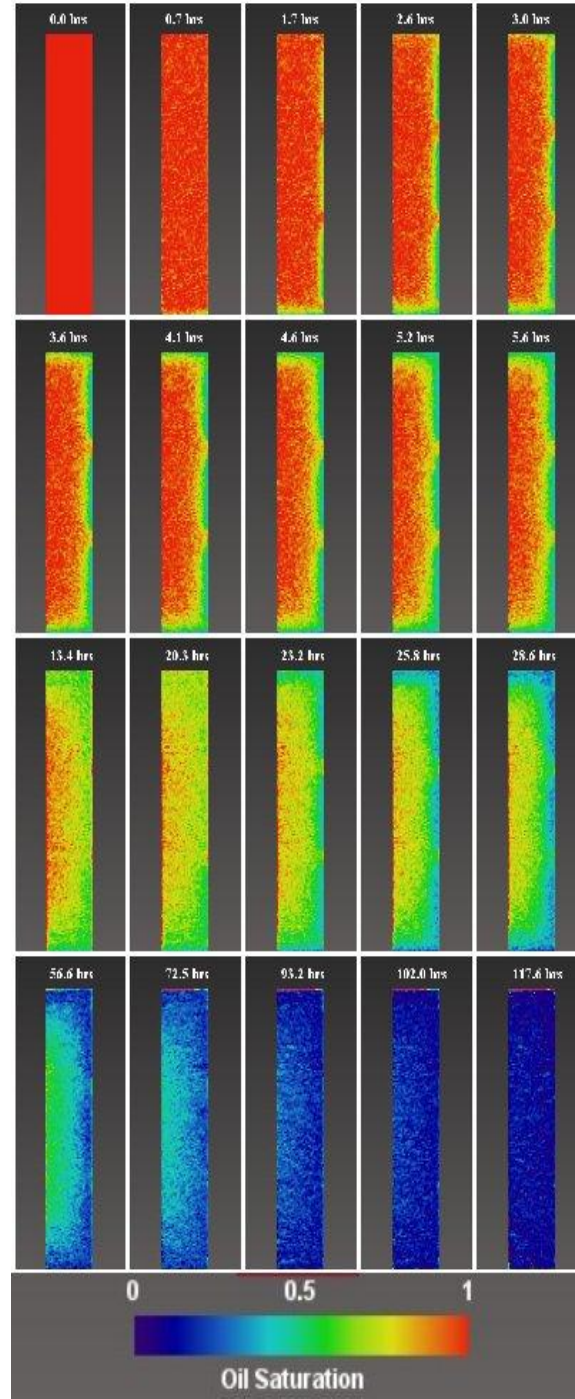
- Model reduced to a simpler system
  - Heterogeneous
  - Negligible gravity effects



CO2 Injection

- Production data from CT-images
- No differential pressure
  - Diffusion dominant
- Model reduced to 1D
  - Center of model



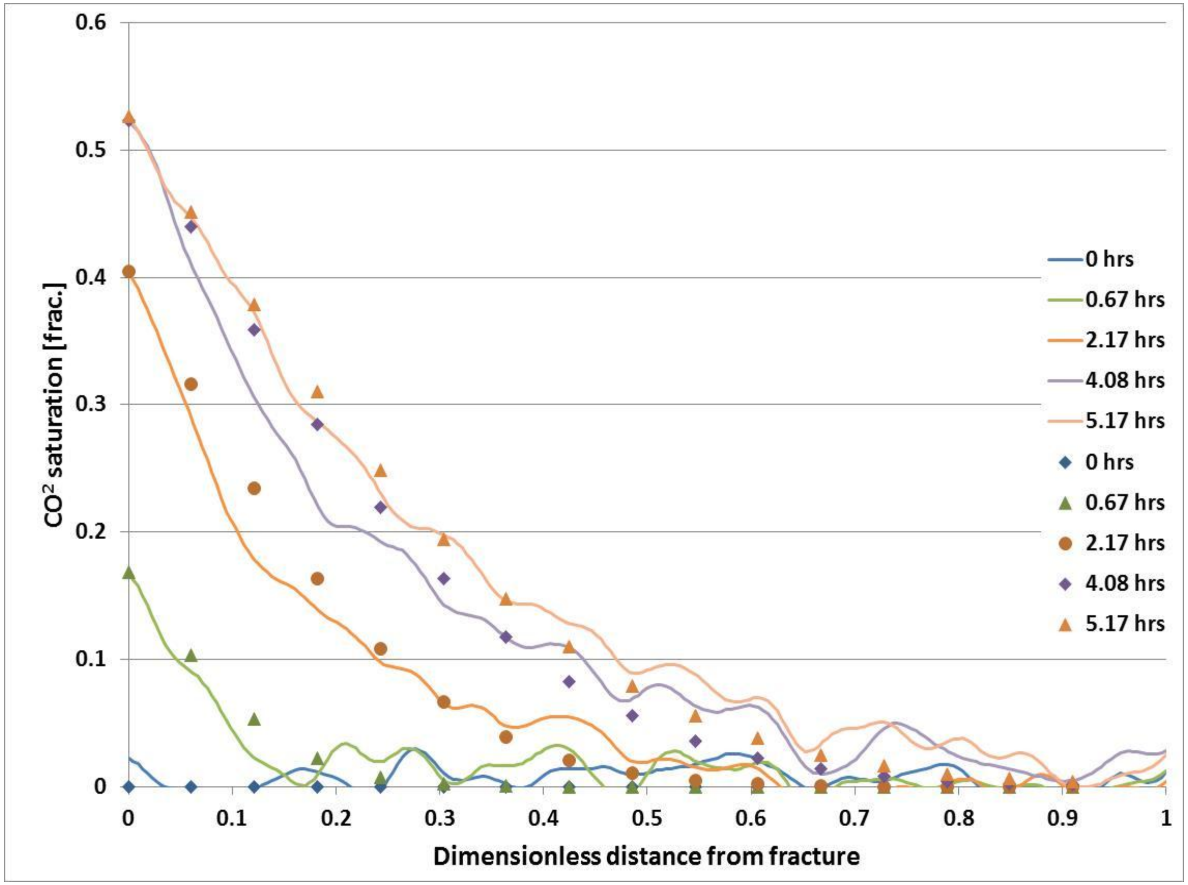


CO2 Injection

$$\frac{\delta C_i}{\delta t} = D_i \frac{\delta^2 C_i}{\delta x^2}$$

$$C_i = C_0 \left(1 - \text{erf}\left(\frac{x}{2\sqrt{D_i t}}\right)\right)$$

- Assumes constant CO2-concentration of 0.9 in the fracture
- 1E-9 m2/s



Conclusions

- Effective diffusion coefficient similar to bulk diffusion coefficient when corrected for tortuosity
- Diffusion is a major driving force during CO_2 injection at core size resolution
- Less dominant at field scale
- Dependent on water saturation
  - Water shielding
  - Effective tortuosity changed
- Dependent on fracture spacing and connectivity
  - Gravity segregation more dominant in fractures
- Asphaltene deposition
- Computationally expensive in simulations

Thank you

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