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Global Climate & Energy Project

STANFORD UNIVERSITY

Water Conformance and Mobility Control by CO2 Exsolution

Lin Zuo, Sally Benson

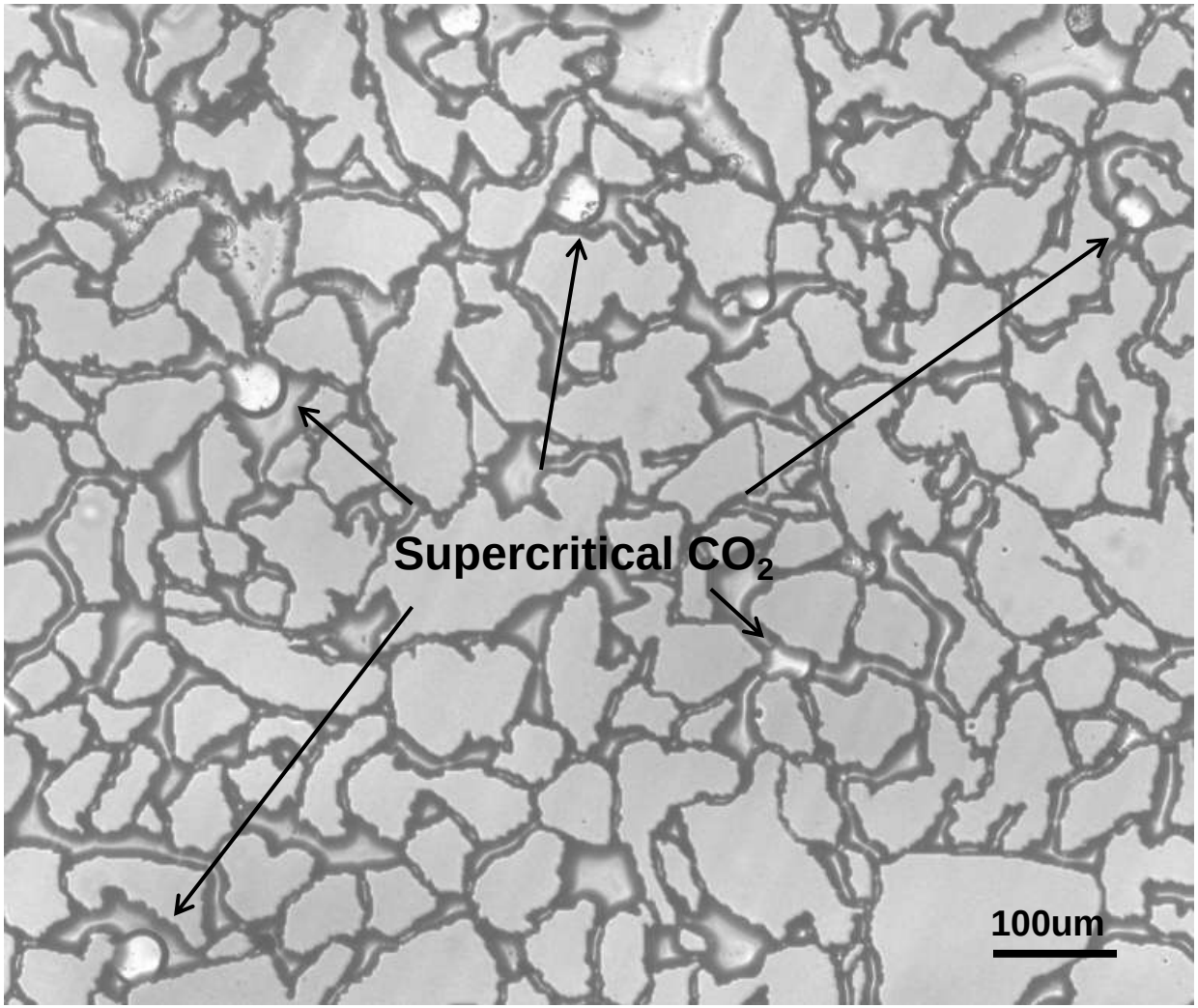
Nov 20, 2013

Collaborative Symposium on CO2 EOR between Universities in Texas and Norway, oil industry in Texas and Norway and other CO2 EOR stake holders

Nov. 19 – Nov. 21, 2013

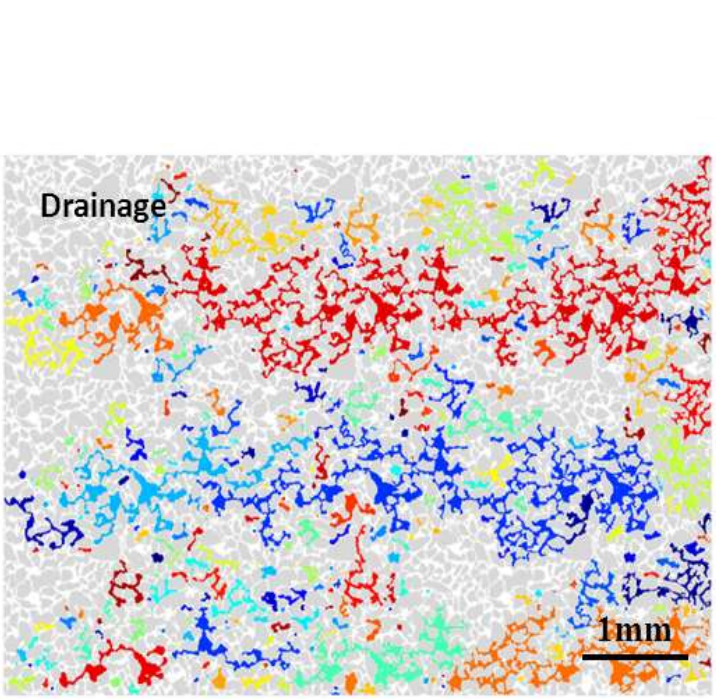
INTRODUCTION

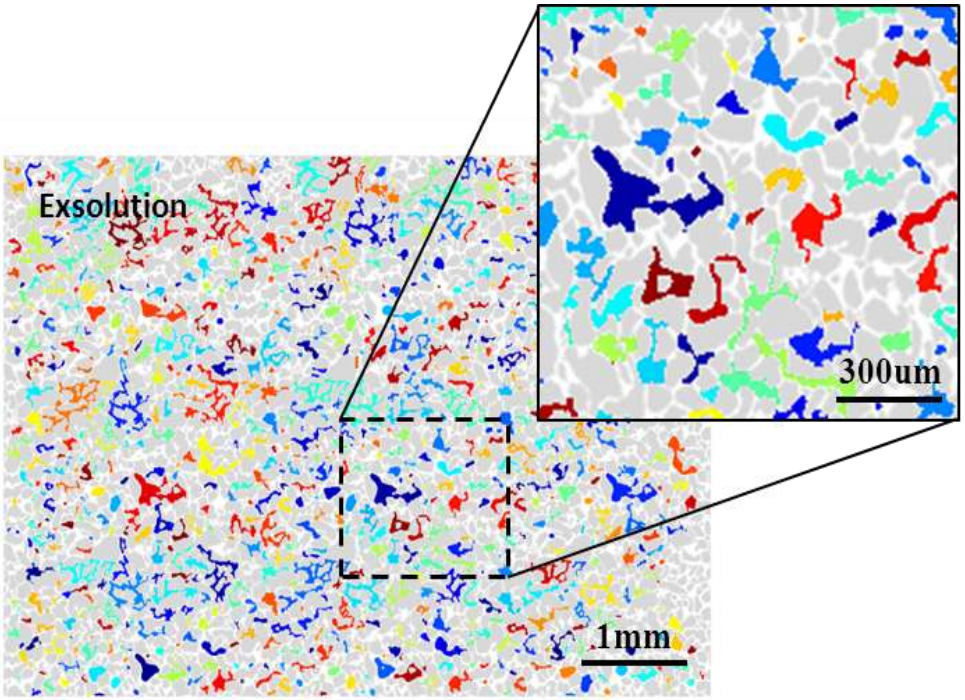
- What is CO_2 exsolution?



INTRODUCTION

- What is the difference between injected CO_2 and exsolved CO_2?

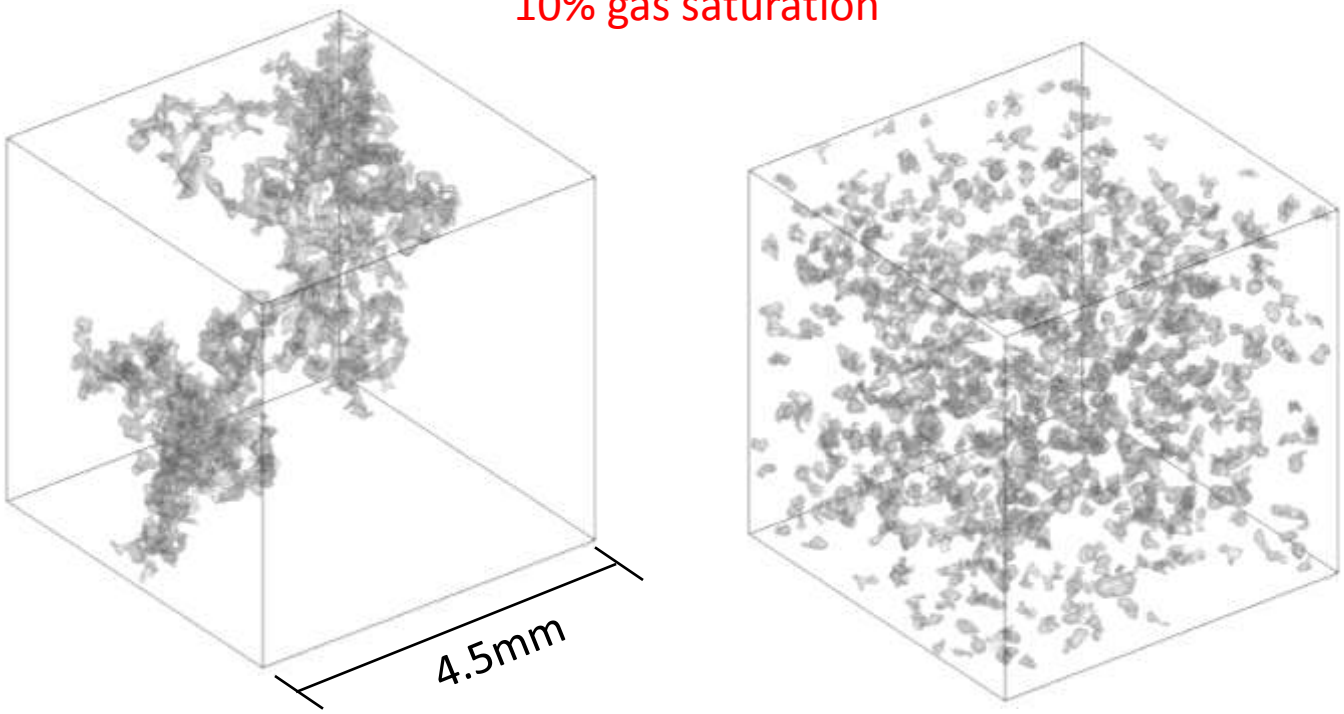




INTRODUCTION

- What is the difference between injected CO_2 and exsolved CO_2?

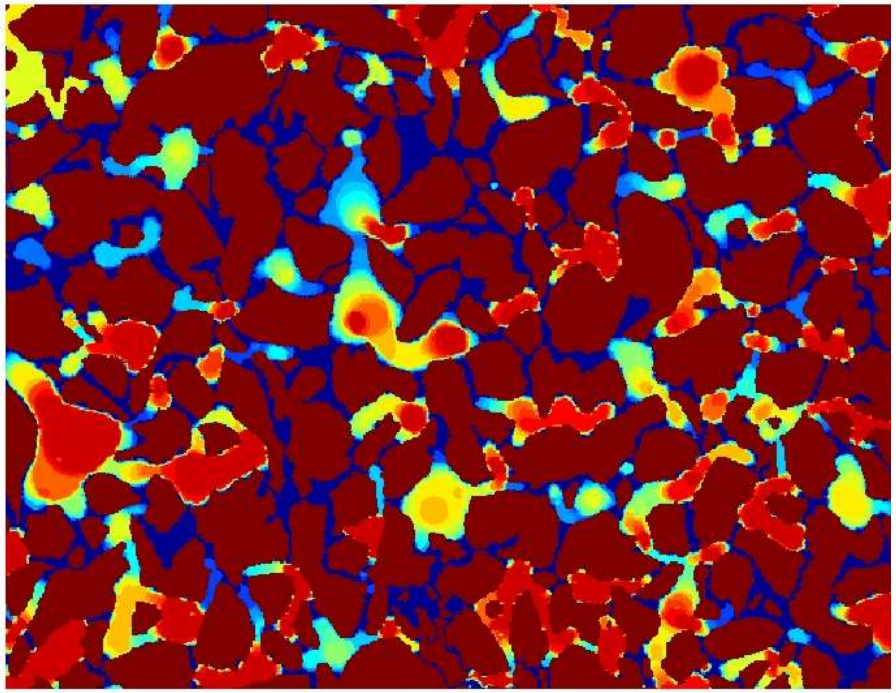
10% gas saturation



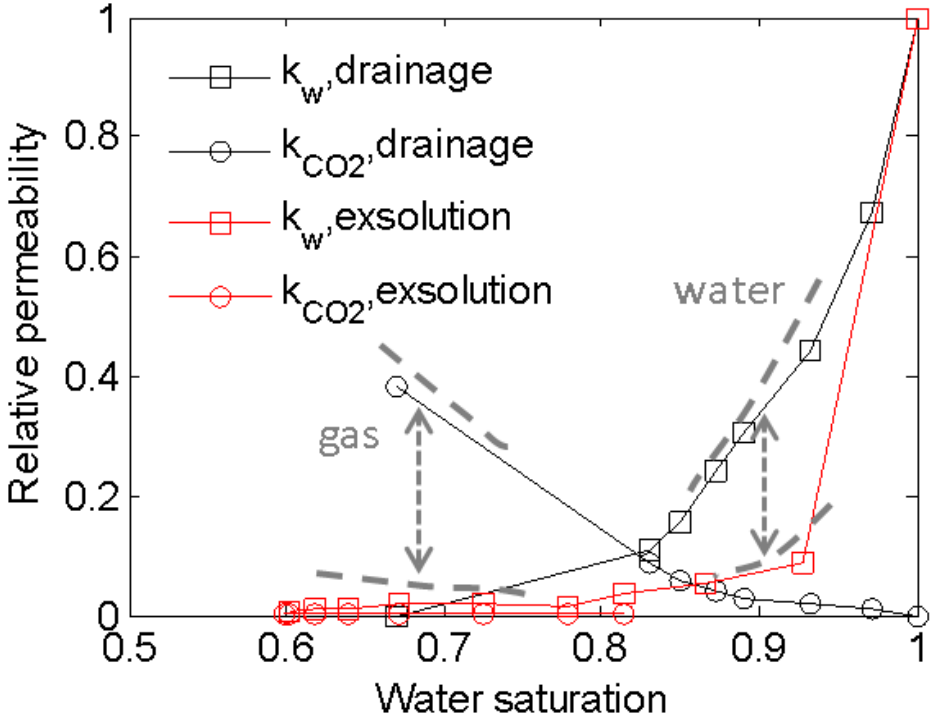
INTRODUCTION

- What are scientific implications?
  - Immobile gas
  - Disproportional water mobility reduction

Bubble Movements

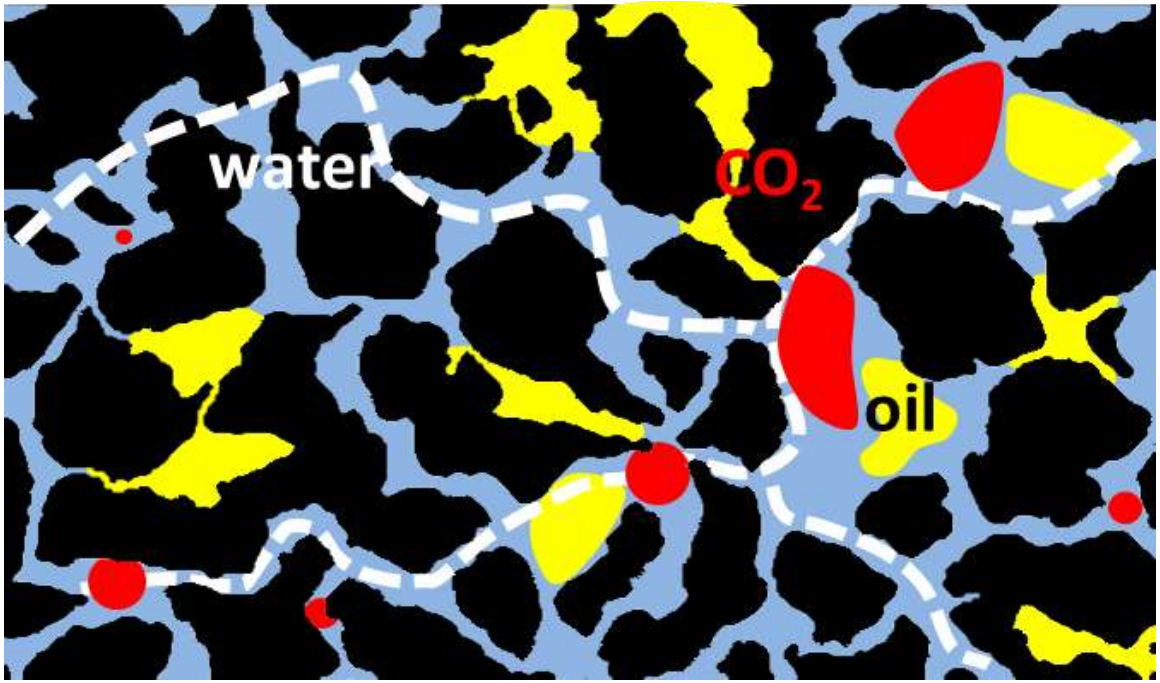


Relative Permeability



EXSOLUTION EOR

- Problems after waterflooding
  - Inefficient spatial displacement
  - Poor pore-scale displacement
- Concept
  - Deliver CO_2 to flooded zones by carbonated water injection
  - Drop pressure -> CO_2 exsolves and plugs established flow paths
  - Establish new flow paths

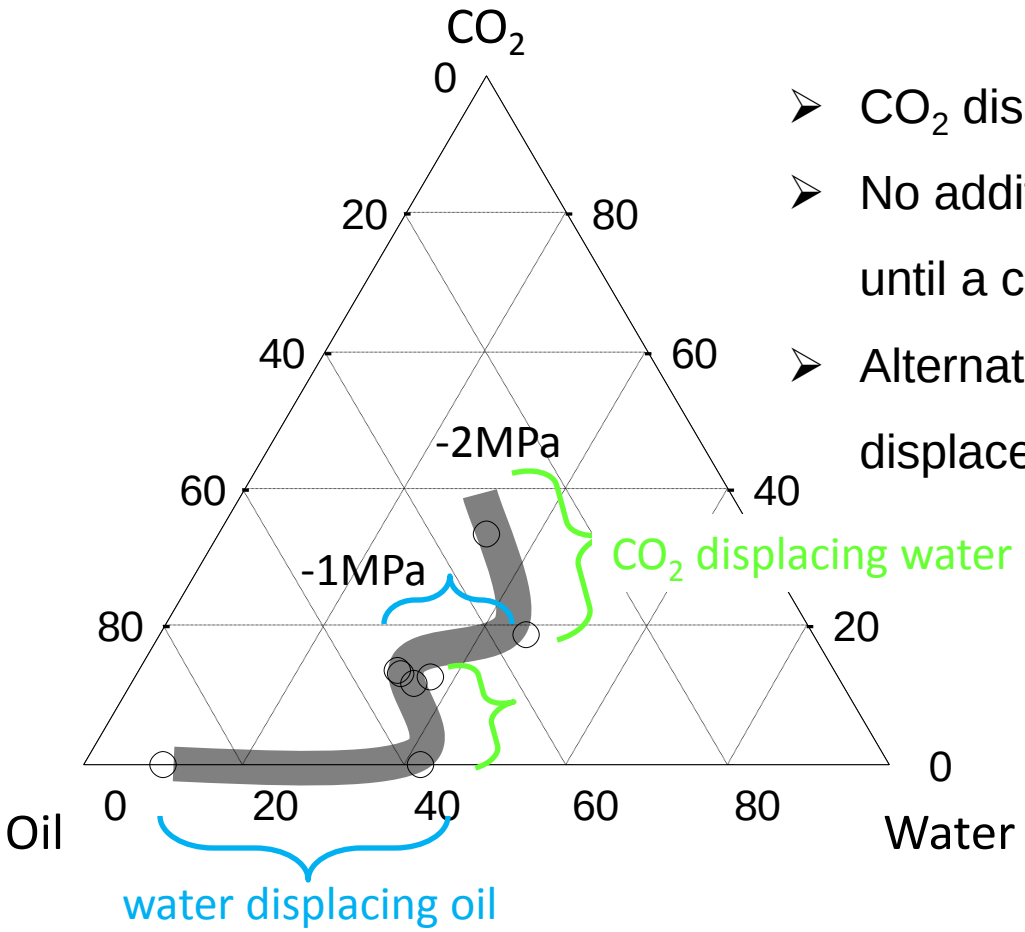


EXSOLUTION EOR

- Micromodel Experiment of Water Conformance
  - Constant injection rate, 1m/day (CA~10^{-7})
  - Constant producer pressure (650psi), 150psi below saturated pressure
  - Viscosity of mineral oil ~ 100 X viscosity of water @ 45C

EXSOLUTION EOR

- Oil/water/CO_2 interaction in Exsolution EOR



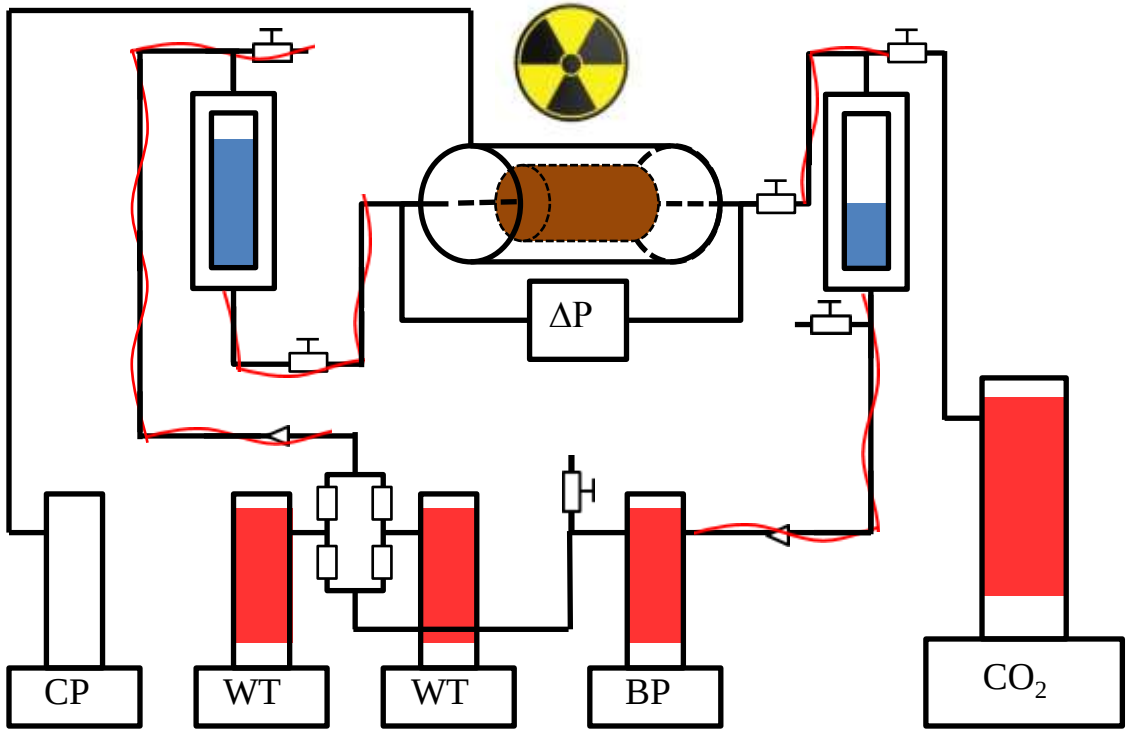
- CO_2 displaces water as exsolution occurs
- No additional oil recovered (by the water) until a certain CO_2 saturation is reached
- Alternating CO_2-water and water-oil displacement

EXSOLUTION EOR

Aluminium Core Holder

Experimental Apparatus

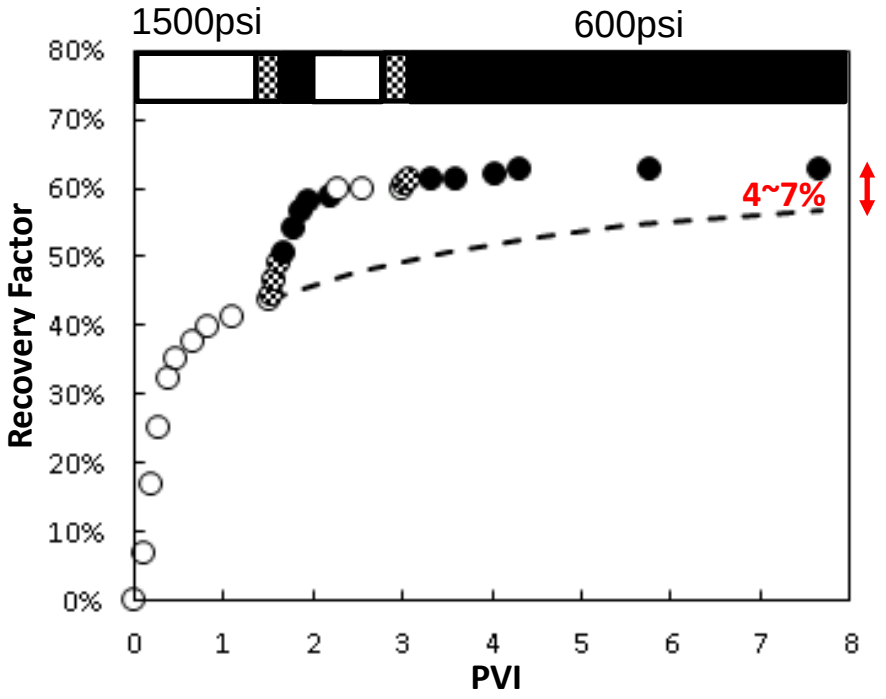
System Schematic

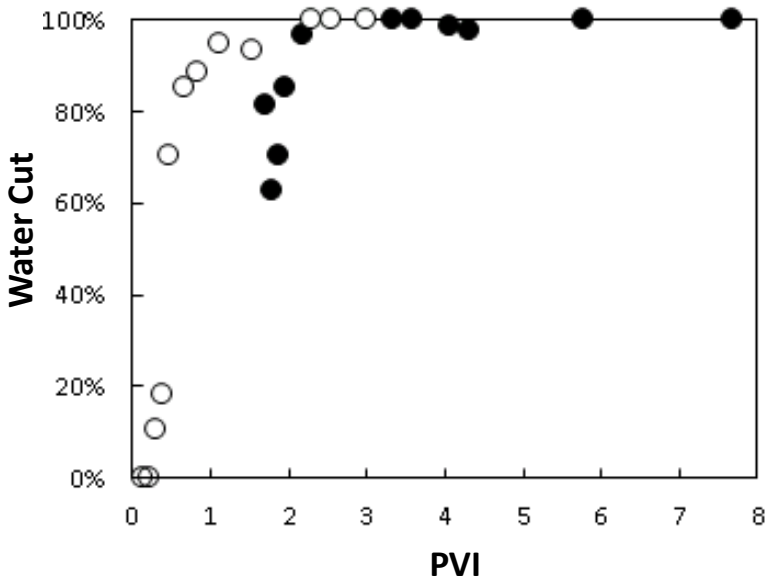


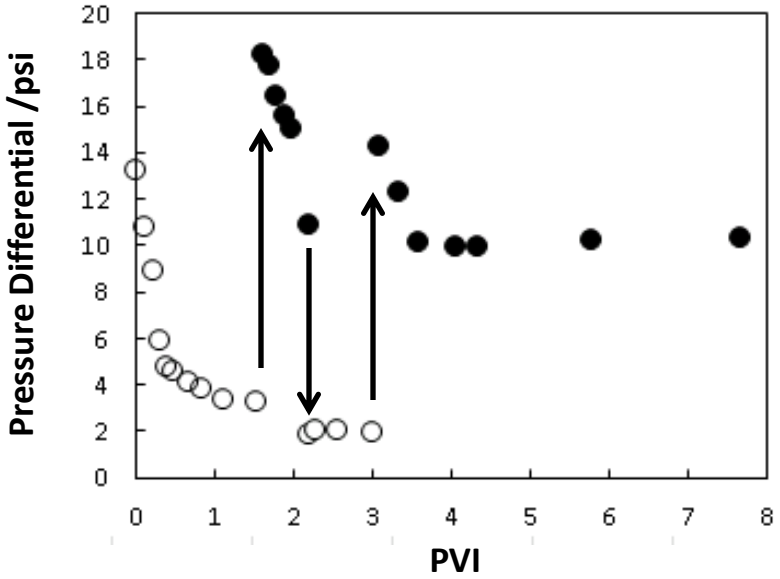
CORE FLOODING EXPERIMENTS

- Berea sandstone
- Constant injection rate, 1m/day (CA~10^{-7})
- Viscosity of mineral oil ~ 100 X viscosity of water

- ○ Carbonated water injection at 1500psi
- ◍ Pressure transition from 1500psi to 600psi
- ● Carbonated water injection at 600psi







CONCLUSIONS

- Effective local mobility control by CO_2 exsolution;
- Production increase with significant less CO_2 use;
- Development potential for water flooded reservoirs (confined, <1500m depth, not for heavy oil).

ACKNOWLEDGEMENT

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