Water Conformance and Mobility Control by CO2 Exsolution

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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$_2$?
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10% gas saturation
INTRODUCTION

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

Bubble Movements

![Bubble Movement Diagram](image)

### Relative Permeability

- $k_{w,\text{drainage}}$
- $k_{\text{CO}_2,\text{drainage}}$
- $k_{w,\text{exsolution}}$
- $k_{\text{CO}_2,\text{exsolution}}$

![Relative Permeability Graph](image)

- Water
- Gas

Relative permeability vs. Water saturation
EXSOLUTION EOR

- Problems after waterflooding
  - Inefficient spatial displacement
  - Poor pore-scale displacement
- Concept
  - Deliver \( \text{CO}_2 \) to flooded zones by carbonated water injection
  - Drop pressure -> \( \text{CO}_2 \) 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

grains & CO₂ bubbles: black; oil: gray; water: green

100μm
EXSOLUTION EOR

- Oil/water/CO₂ interaction in Exsolution EOR

- CO₂ displaces water as exsolution occurs
- No additional oil recovered (by the water) until a certain CO₂ saturation is reached
- Alternating CO₂-water and water-oil displacement
EXSOLUTION EOR

Aluminium Core Holder

Experimental Apparatus

System Schematic

- CP
- WT
- WT
- BP
- CO₂
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).

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