CARBON CAPTURE, UTILIZATION & STORAGE CONFERENCE

JUNE 14-16, 2016 | SHERATON TYSONS CORNER | TYSONS, VA

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Inaccuracy of End Points of CO_2-Brine Relative Permeability Curves

Adverse Effect of Low Capillary Pressure during Testing and Proposed Solution

(New Core Holder to Boost Capillary Pressure)

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Overview

- Importance of CO_2-brine relative permeability
- Status of CO_2-brine relative permeability data
- Evidence of CO_2-brine relative permeability inaccuracy
- Conventional test set up
- Numerical simulation of conventional test setup
- Reasons for CO_2-brine relative permeability uncertainties
- Effect on simulation of CO_2 storage projects
- Proposed new core holder

Importance of CO_2-Brine Relative Permeability

- CO_2-brine relative permeability affects:
  - Numerical simulations
  - Flow and movement of CO_2 and brine
  - Well injectivity index
  - Number of injection wells
  - Residual trapping of CO_2

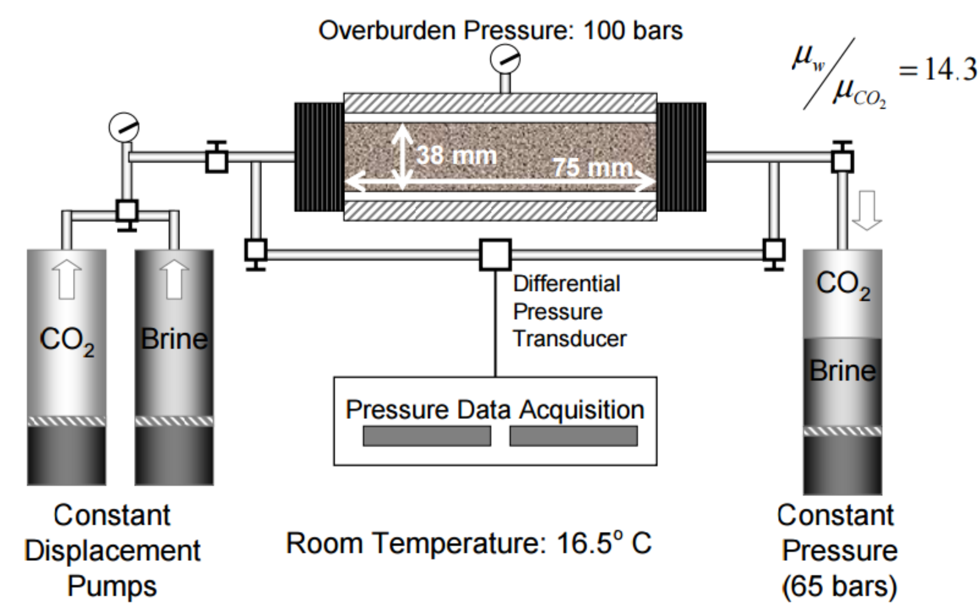
Status of existing CO_2-Brine Drainage and Imbibition Relative Permeability Curves

- Available data very limited
- Data associated with uncertainty
- Max CO_2 saturations low (less than 0.5, normally close to 0.9); especially, in high permeability core samples
- Max CO_2 relative permeability abnormally low ($k_{rCO2max} < 0.4$, normally close to 1); especially, in high permeability samples

Low endpoint attributed to Conventional Test setup (especially high permeability core samples)

- CO_2 viscosity relative to brine very low
- Length of test core is short
- Differential pressure is low in high permeability sample ; therefore, produce low capillary pressure

➢ customary core flood setup not suitable



Wiltgen et al.(2003)

Why CO_2-Brine Relative Permeability Curves Are Flawed

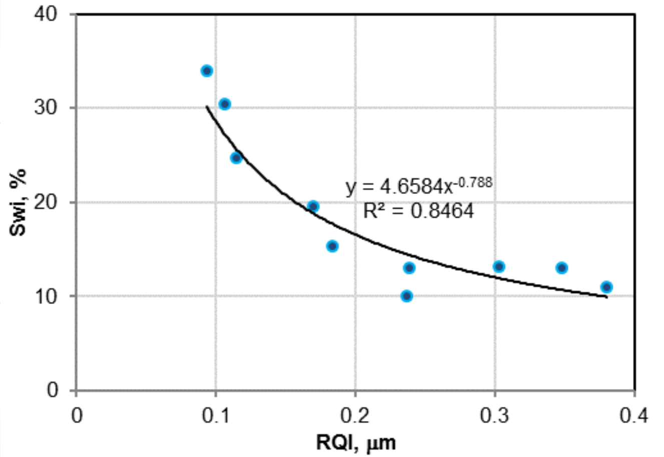
Effect of permeability

❑ In high permeability test cores:

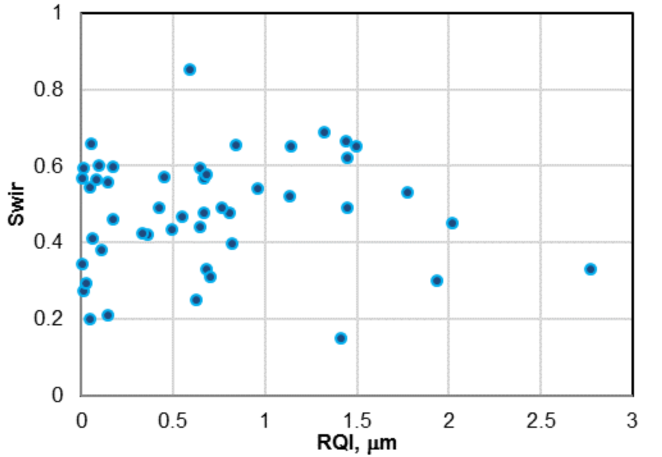
- Low differential pressure across test core at 100% CO_2 flooding
- Average capillary pressure in test core at 100% CO_2 flood less than differential pressure and low
- Max CO_2 saturation low because of low imposed capillary pressure
- Max relative permeability to CO_2 also low

Evidence that CO_2-Brine Relative Permeability Curves are Flawed

Correlation between Swir and RQI

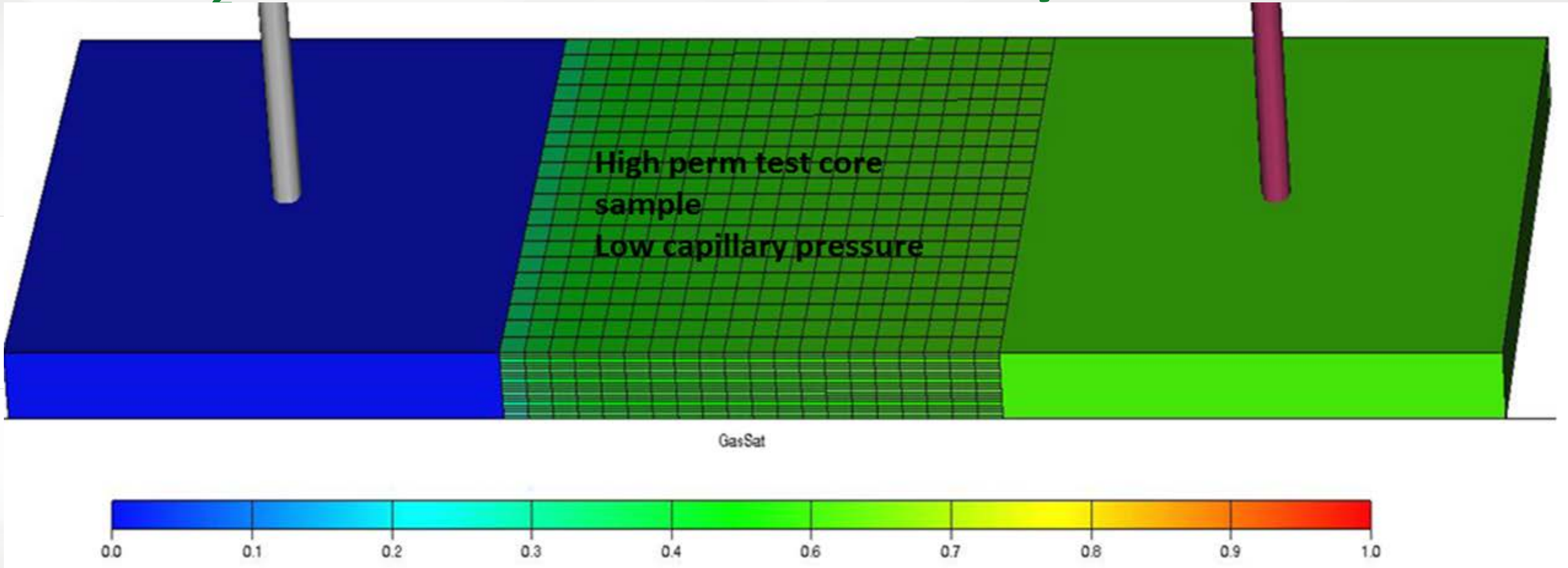


Oil-water system (good correlation)



CO_2-brine system (no correlation)

Numerical Simulation of Conventional Test Setup for CO_2-Brine Relative Permeability



At 100% CO_2 flow: kr_{CO2} of 26% , Swir of 41%

Results from Simulation of Conventional Test Setup

Dependency of end points to test condition

❑ At 100% CO_2 flooding:

- Increase in rate of CO_2 increases its end points
- Increase in viscosity increases CO_2 end points
- Increase in permeability decreases CO_2 end points

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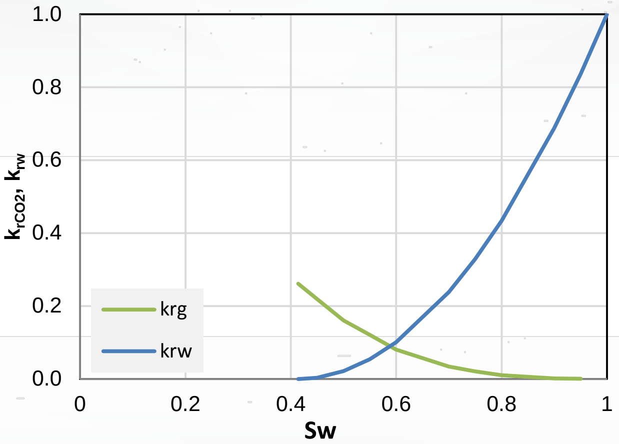
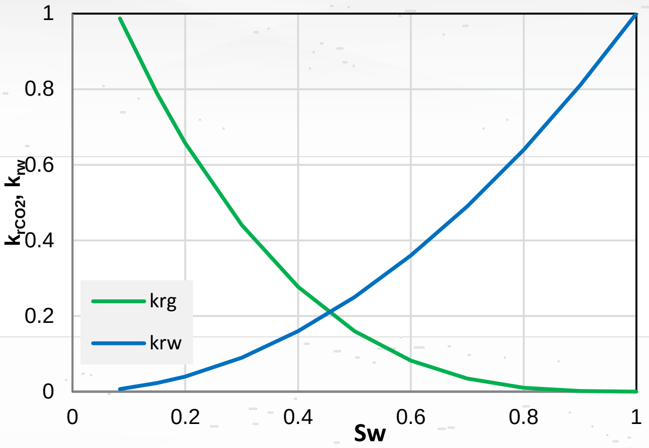
Measured and Real CO_2-Brine Relative Permeability

High Permeability Sample



Measured Rel Perm



Correct Rel Perm

Why CO_2-Brine Relative Permeability Curves Are Flawed

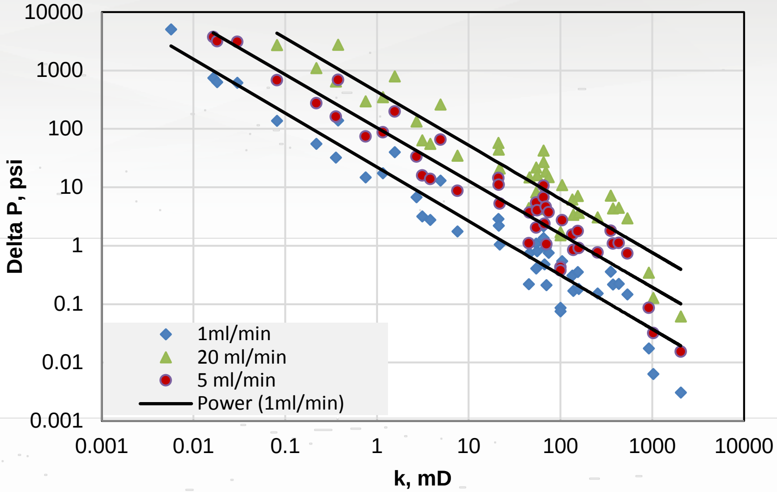
Effect of permeability

❑ In low permeability test core:

- High differential pressure
- High capillary pressure
- low Sw and high S_{CO2}

❑ In High permeability test core:

- Low differential pressure
- Low capillary pressure
- High Sw and Low S_{CO2}



Differential pressure across the core vs. core permeability

Adverse Effect on Numerical Simulation of CO_2 Injection in Deep Saline Formations

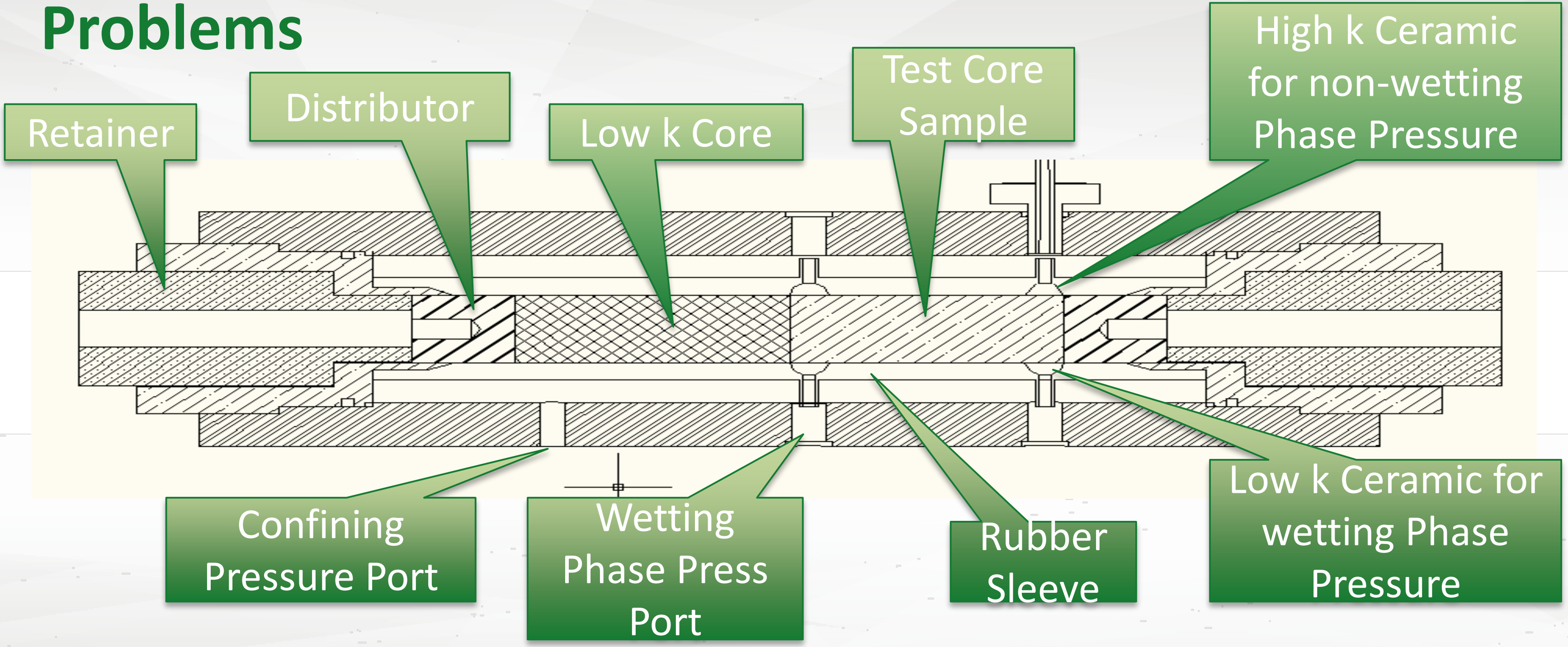
❑ In reality S_{CO2} at top reaches 90% when:

- Formation horizontal perm is good
- Vertical perm is poor
- Large CO_2 plume is formed
- Plume thickness is 100 ft or more
- Pc at top of plume is >30 psi

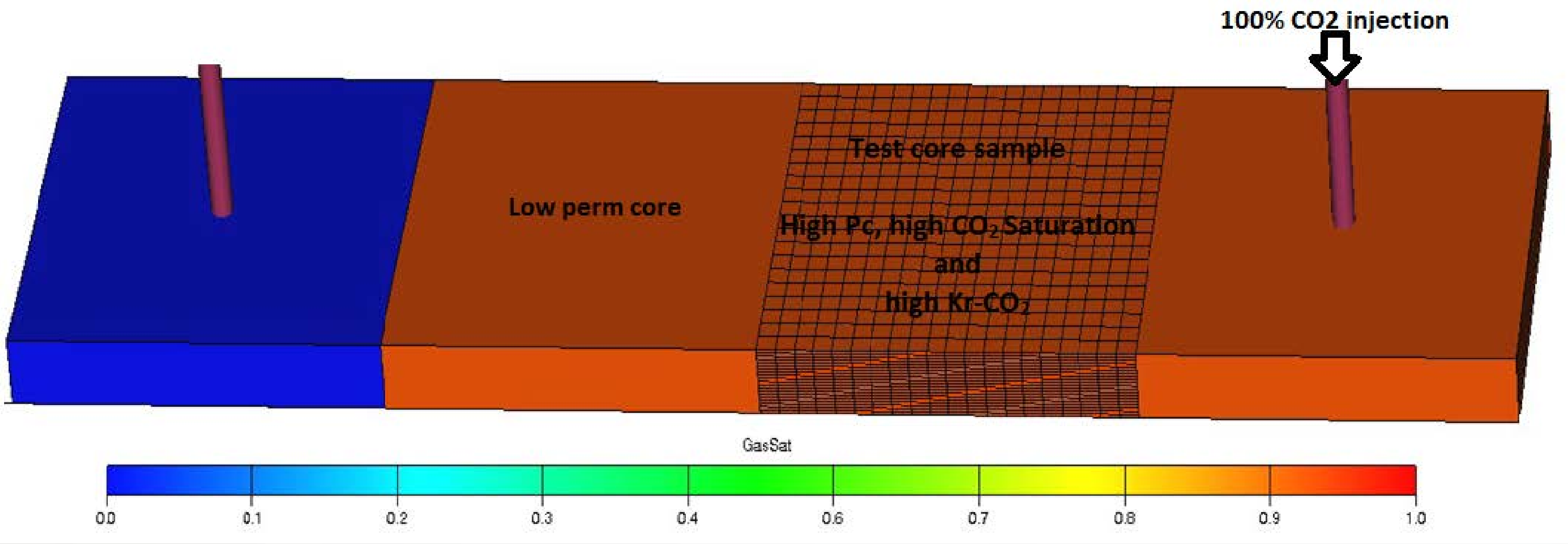
❑ In simulation it would not exceed 60%

- Max drainage S_{CO2} inaccurate in simulation grids
- Residual trapping of CO_2 inaccurate in simulation cells because residual saturation depends on initial saturation

Proposed New Core Holder Solves Uncertainty Problems



Numerical Simulation of New Core Holder



Results - Numerical Simulation of New Core Holder

- Correct endpoints were produced
- End point not influenced by viscosity
- End points not affected by rate of flow
- End points not influenced by permeability of test core sample

Participants

- Thanks are extended to KGS for their support and Julie Tollefson at KGS for her review of this work

Acknowledgements & Disclaimer

Acknowledgements

- *The work supported by the U.S. Department of Energy (DOE) National Energy Technology Laboratory (NETL) under Grant DE-FE0002056 and DE-FE0006821, W.L. Watney and Jason Rush, Joint PIs. Project is managed and administered by the Kansas Geological Survey/KUCR at the University of Kansas and funded by DOE/NETL and cost-sharing partners.*

Thank you!