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100 years of living science 100

CO_2 Storage in Aquifers and Oilfields

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Dec 7, 2009

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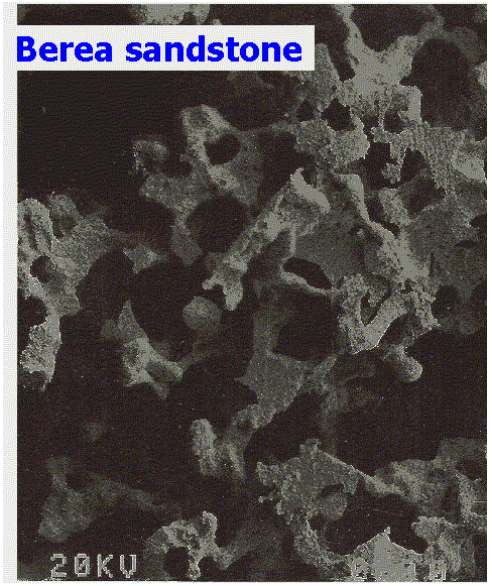
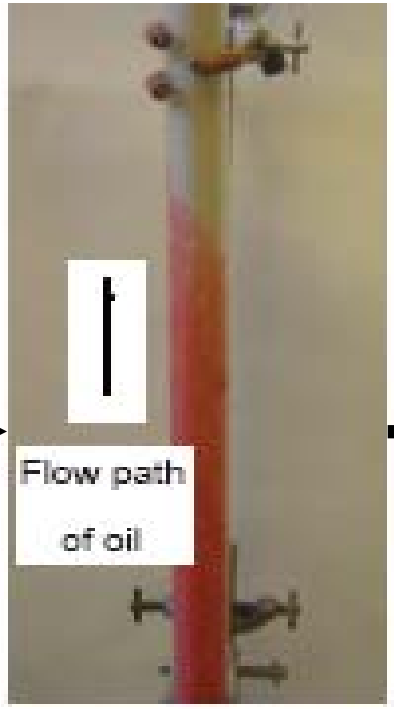
Spread of CO_2 is an inherently multi-scale process



Pore scale:

Model flow through pores directly

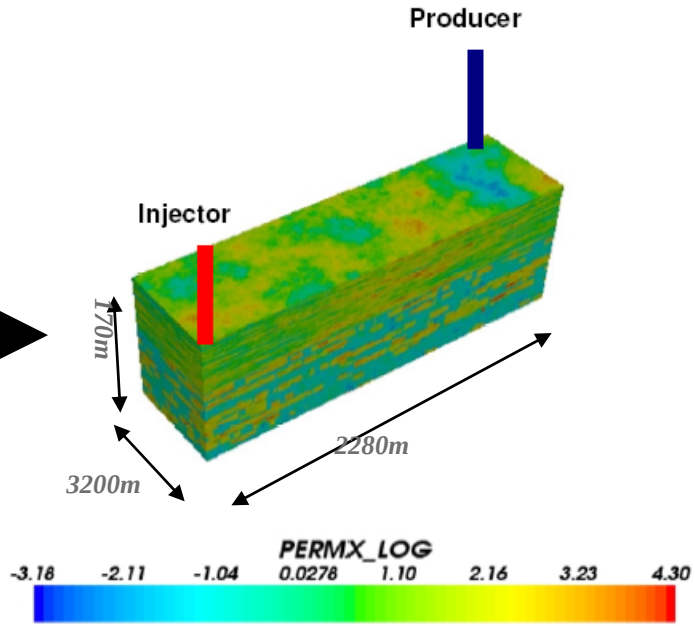
⌈m-mm



Laboratory scale:

Model flow using continuum approximation

cm-m



Field scale:

Model flow using continuum approximation

m-km

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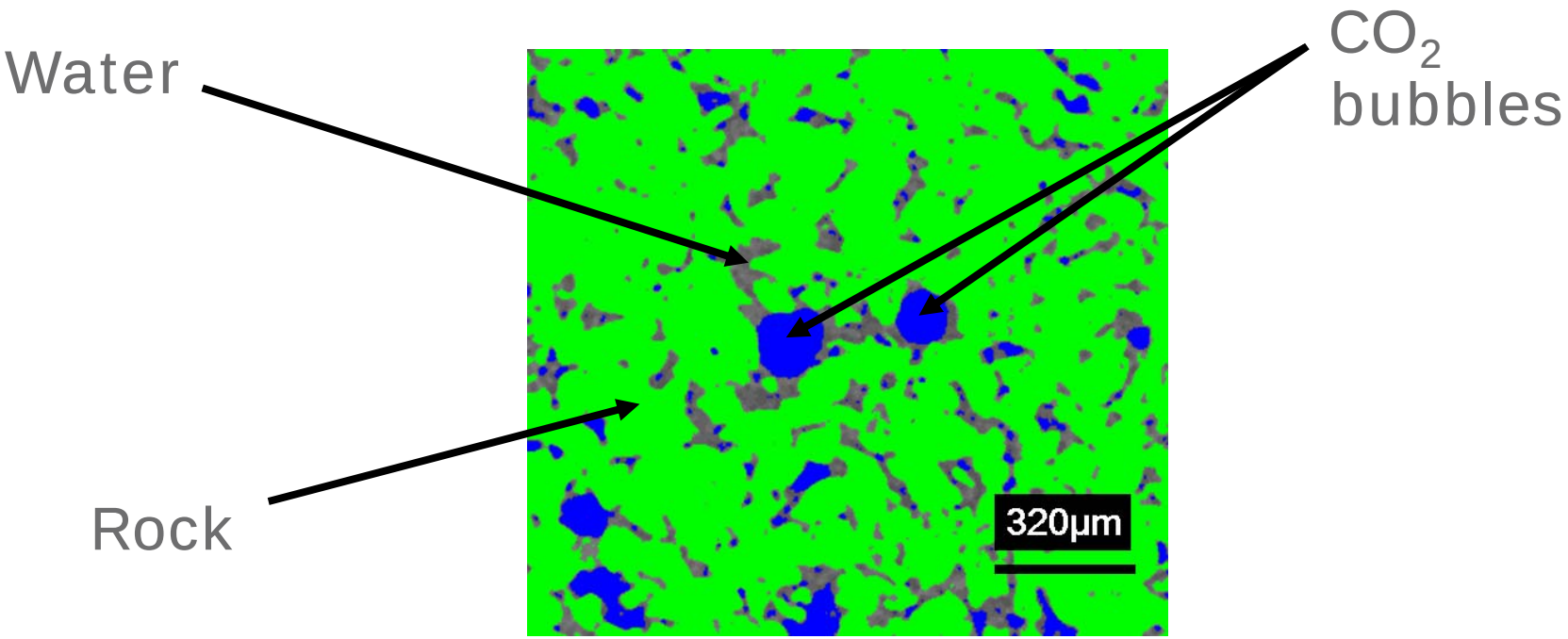
CO_2 trapping

As CO_2 migrates through the rocks, it is trapped in pore-scale bubbles that can not move further



Dong, 2007

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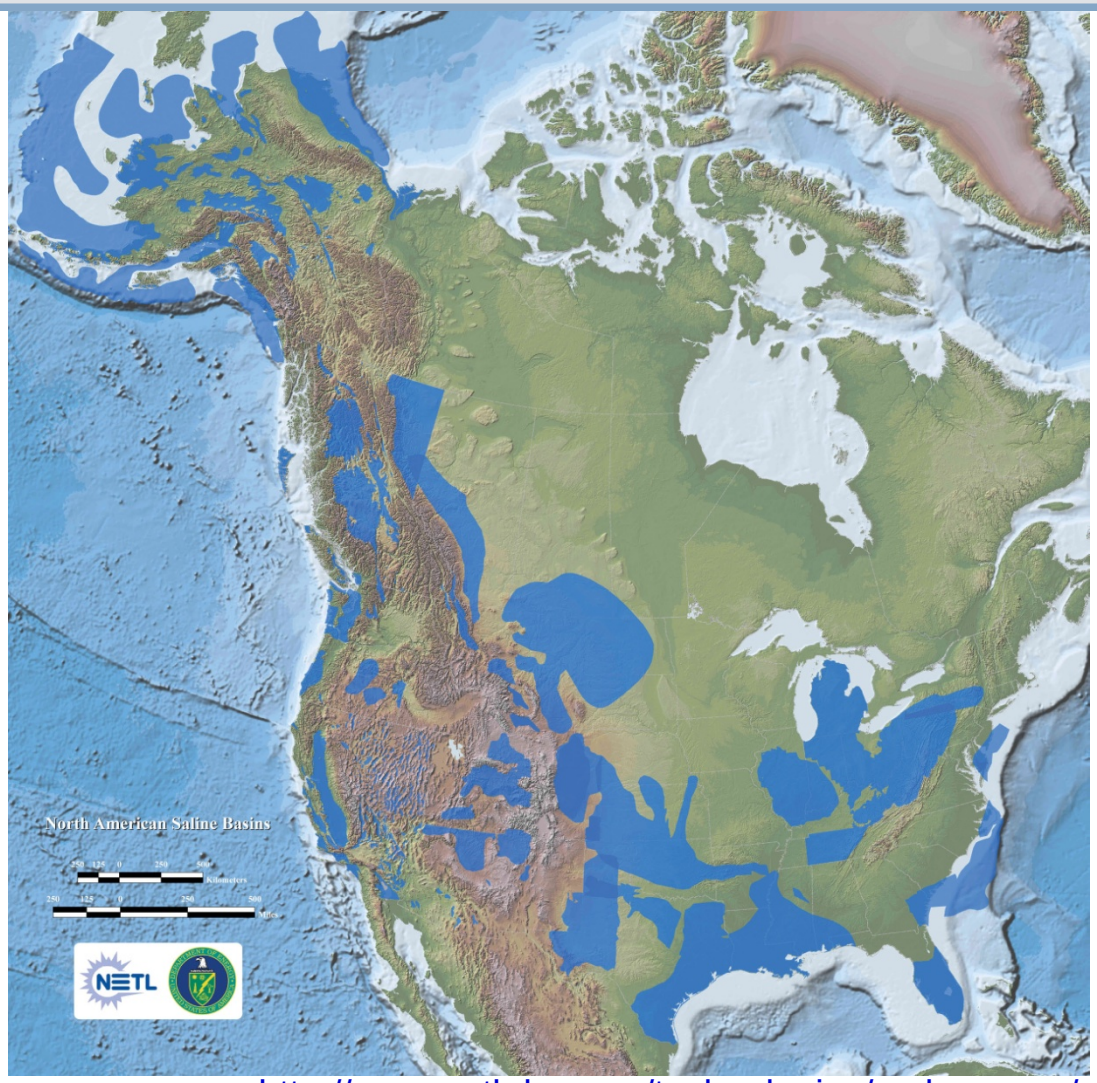
Aquifer storage



http://www.netl.doe.gov/technologies/carbon_seq/refshelf/atlas/index.html

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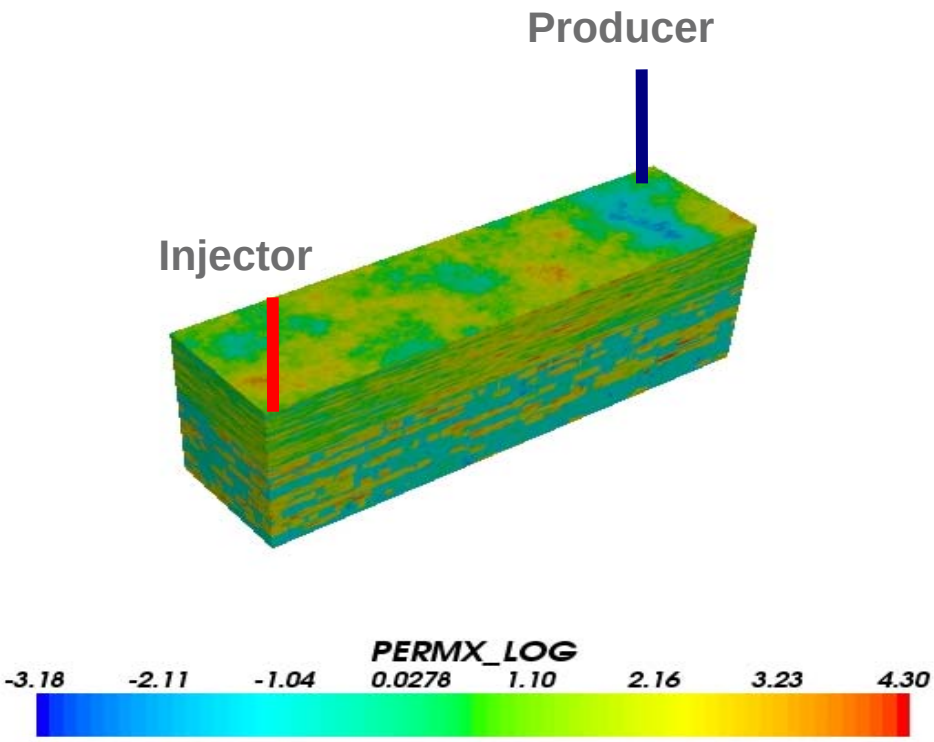
Design of carbon dioxide storage in aquifers

A case study on a highly heterogeneous field:

- Use chase water to trap CO_2 during injection
- 1D results are used to design a stable displacement
- Simulations are used to optimize trapping



SPE 10 reservoir model, 1,200,000 grid cells (60X220X85), 7.8 Mt CO_2 injected.

Qi et al., JGGC, 2008

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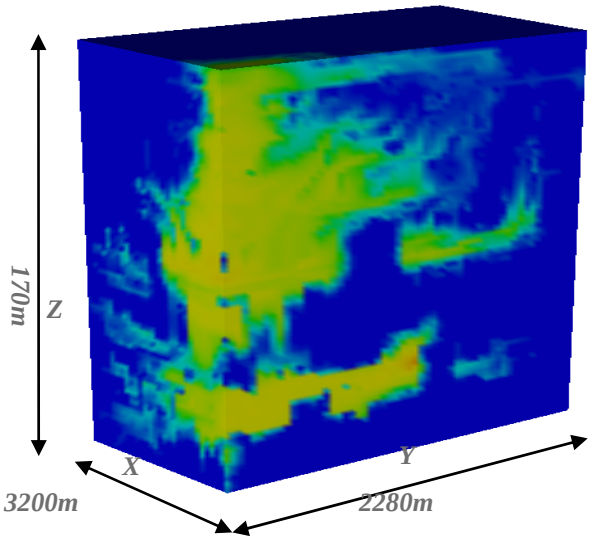
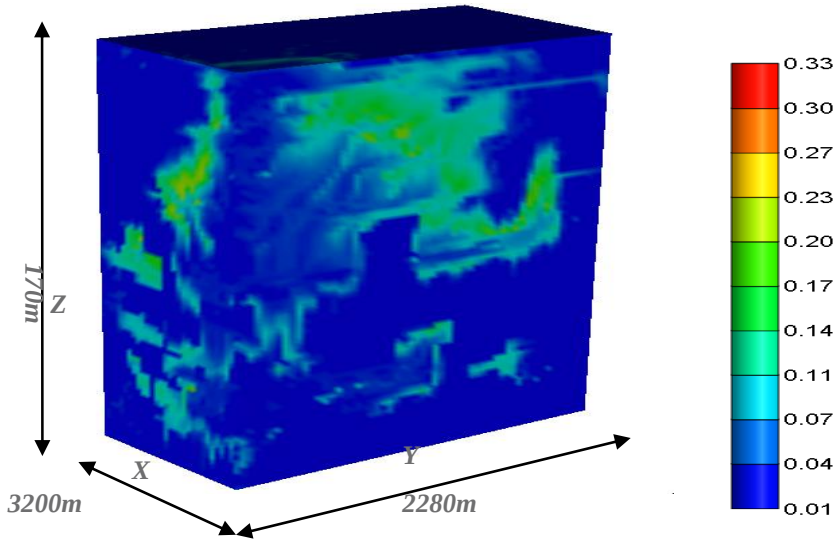
3D results for aquifer storage

20 years of water and CO_2 injection followed by 2 years of water injection in realistic geology

95% of CO_2 trapped after 4 years of water injection



Trapped CO_2 saturation



Mobile CO_2 saturation

Qi et al., JGGC, 2008

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General injection strategy

To maximize CO_2 storage in an aquifer:

- Inject maximum fraction of CO_2 possible with a stable displacement
- Inject chase brine that is 25% of the CO_2 mass
  - 90-95% of the CO_2 is trapped for most realistic case
  - As little as 65% may be trapped for worst case
  - It all rests on how much is trapped as a function of initial saturation.

Qi et al., JGGC, 2008

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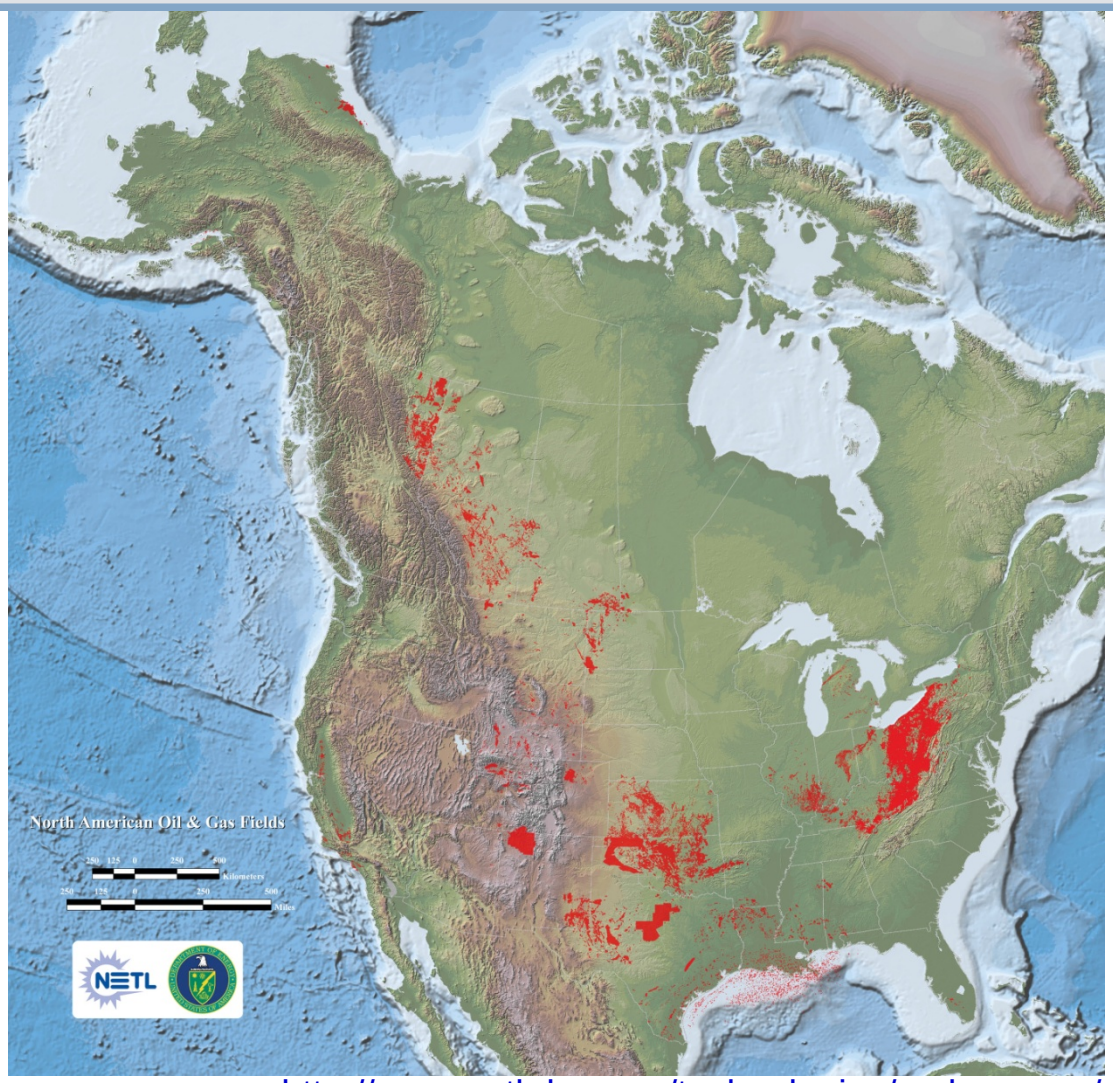
Storage in oil and gas reservoirs



http://www.netl.doe.gov/technologies/carbon_seq/refshelf/atlas/index.html

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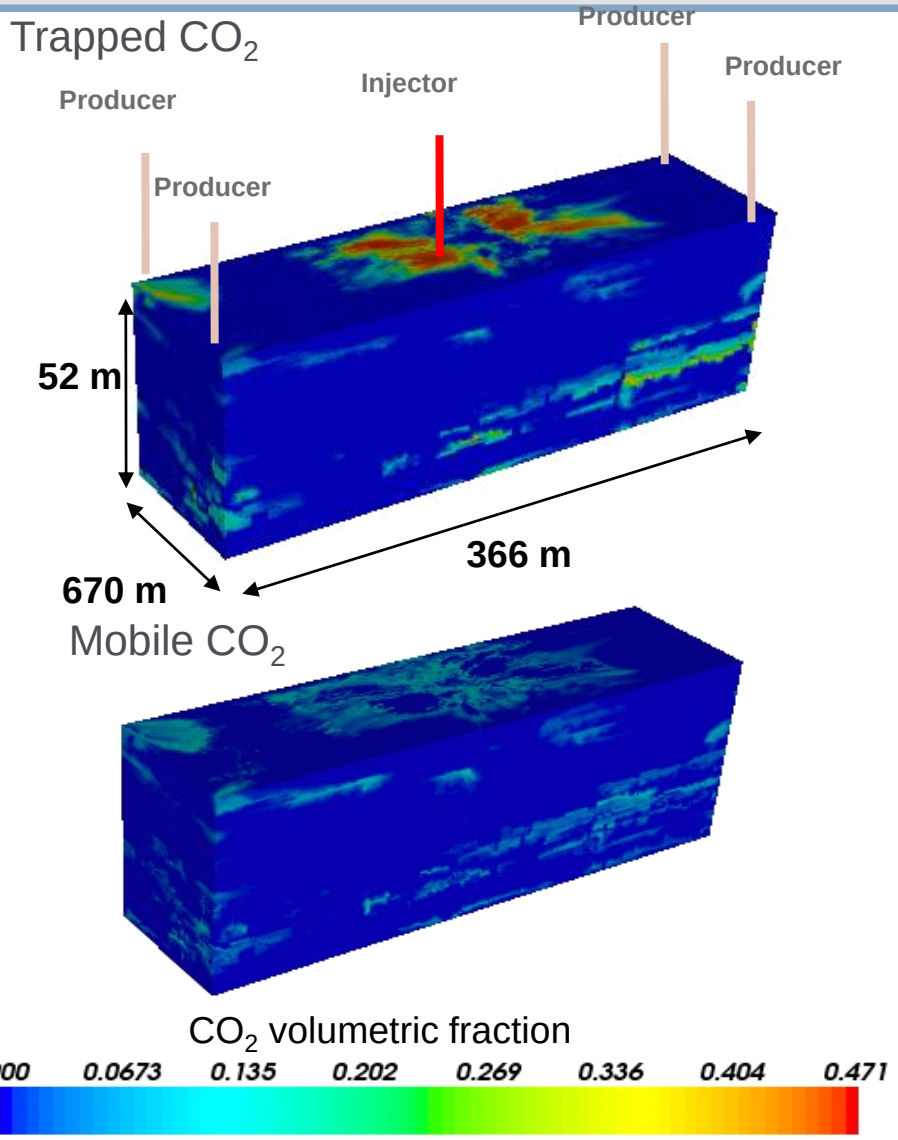
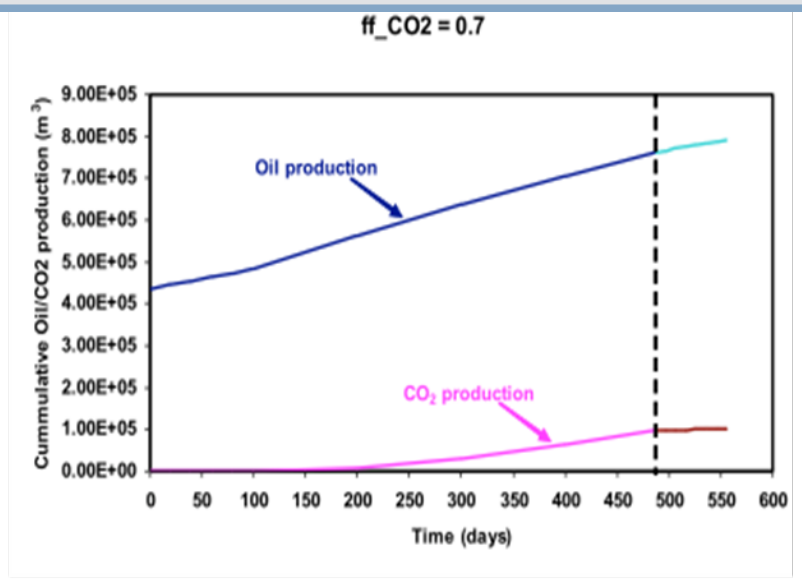
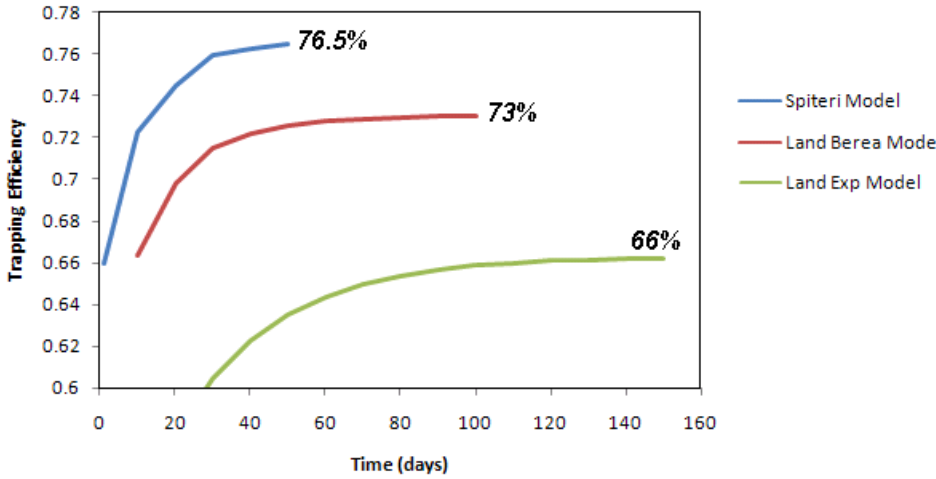
3D results for reservoir storage







Qi et al., SPE 115663

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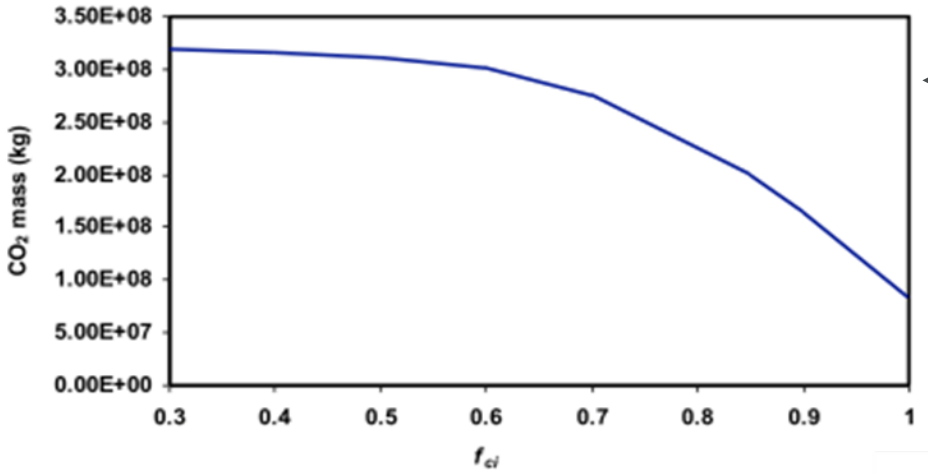
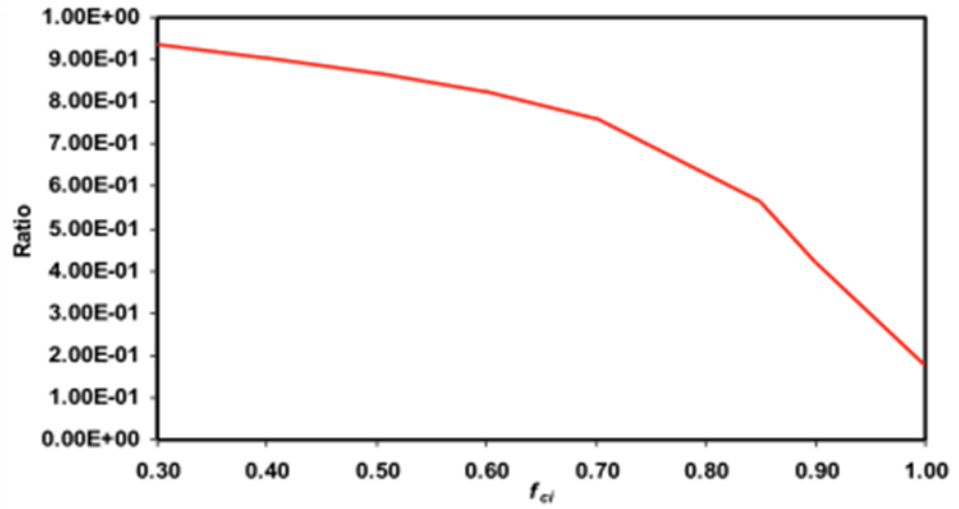
Simulation results for reservoir storage



Mass of CO_2 stored when excessive gas cycling ends project

Ratio between the mass of incremental oil and mass of CO_2 stored



❖SWAG Injection at WAG ratio = 0.5 is suggested in this case.

Qi et al., SPE 115663

Conclusions

- Our study showed that brine + CO_2 injection can trap
  - Up to 95% of the CO_2 in aquifers
  - Up to 75% of the CO_2 in producing oil fields
- Results are very sensitive to trapping model, we need to gather more experimental data

A few open questions

- When is leakage most likely to occur in aquifers?
- How realistic are storage capacity estimates?
- Incremental oil has a CO_2 footprint when burned: Should these emissions be accounted for, and if so how?

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Current work:

Shell Grand Challenge on Clean Fossil Fuels

- Phase 2 has just been funded

Grantham Institute for Climate Change

- Near-well precipitation/dissolution problems in CO_2 injection

EPSRC

- Move to fully compositional three-phase model
- Switch to higher-order numerical methods to guarantee convergence
- Test codes on CO_2 storage demonstration project

Imperial College Centre for Carbon Capture and Storage

- Industrial Consortium IC^4S IC
- An on-campus focal point for CCS research

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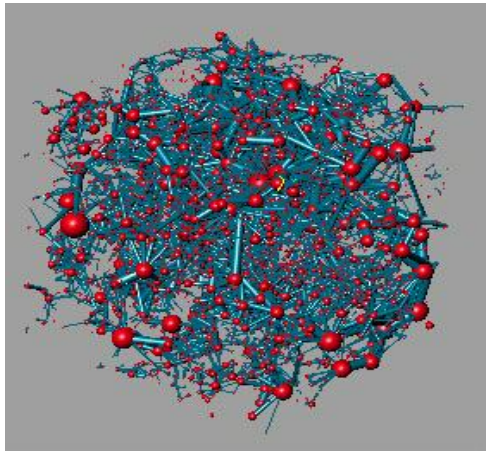
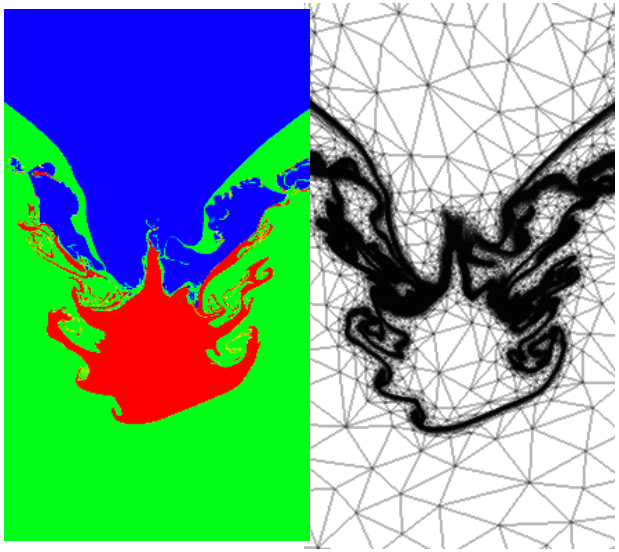
Qatar Carbonates and Carbon Storage Research Centre (Shell/QP)

Project 1: carbonate geology: fracturing and diagenesis

Project 2: pore/fracture-scale physics and chemistry.

Project 3: Integrated Simulator for Carbonate Reservoirs.





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Thanks To:

All of you for listening!

British Consulate-General