Carbon Storage

Integrating Experiments & Modelling to Quantify Trapping Capacity & Efficiency in the Subsurface

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MEASURING TRAPPING CAPACITY

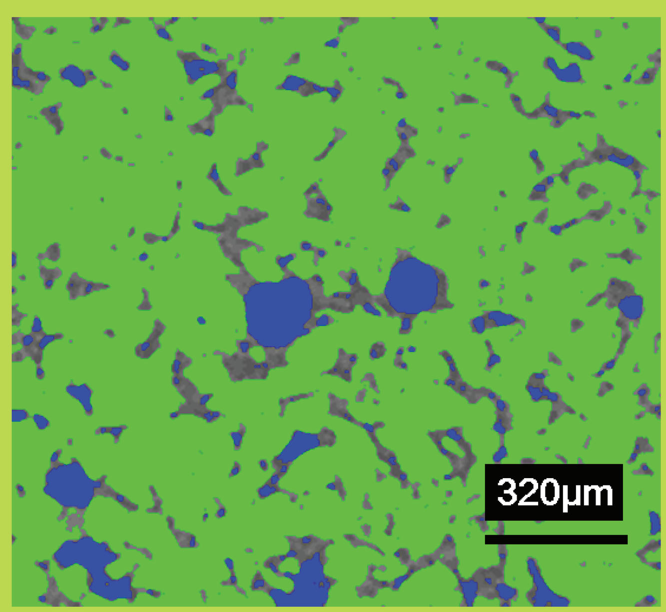
This is a fundamental study of trapping of non-wetting fluids in porous media. When injecting CO_2 into an aquifer for carbon storage, the non-wetting phase (CO_2) is trapped due to capillary forces.

MOTIVATION

Capillary trapping is one of the quickest and most secure means to render CO_2 immobile.

Water, the wetting phase, displaces CO_2 and leaves behind disconnected ganglia of CO_2 in pores:

- rock matrix: green
- water: grey
- CO_2: blue



Micro-CT image of capillary trapping

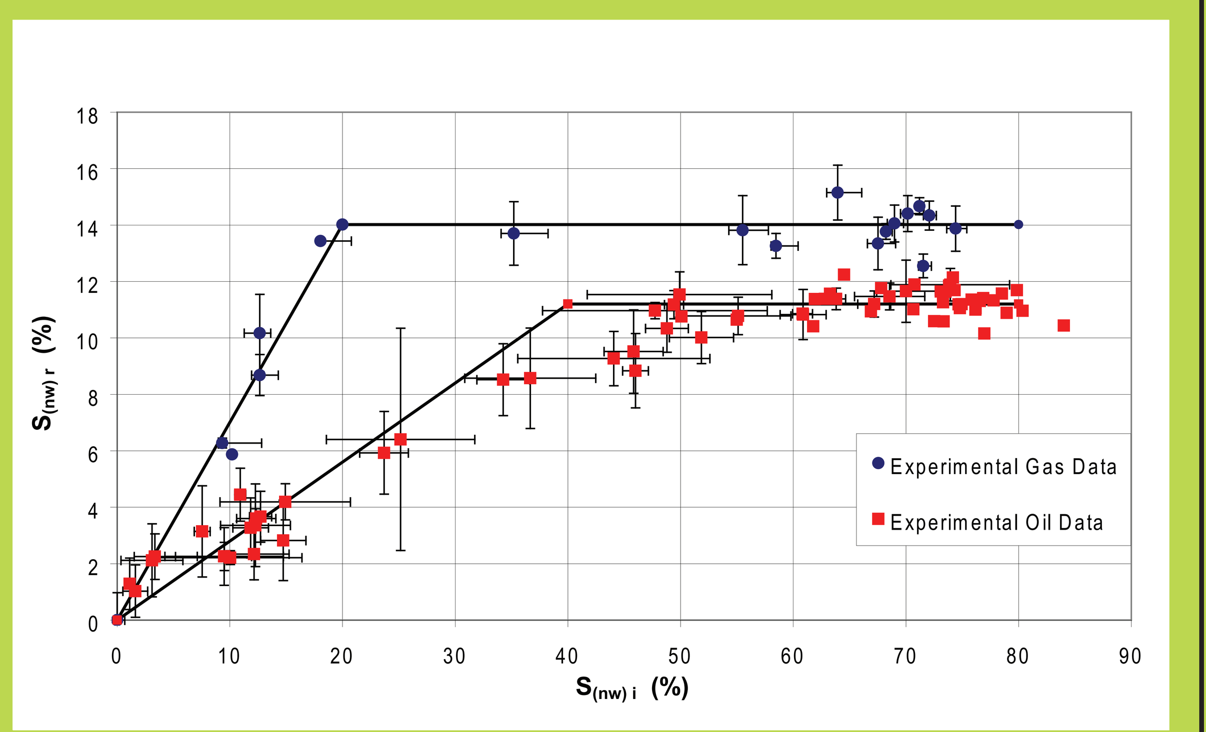
How much CO_2 is trapped?
How does trapping vary with initial CO_2 saturation?

EXPERIMENTS

Horizontal and vertical core floods with analogue fluids.

Oil/water system - oil density similar to scCO_2 denisty.
Gas/water system - gas viscosity similar to scCO_2 viscosity.

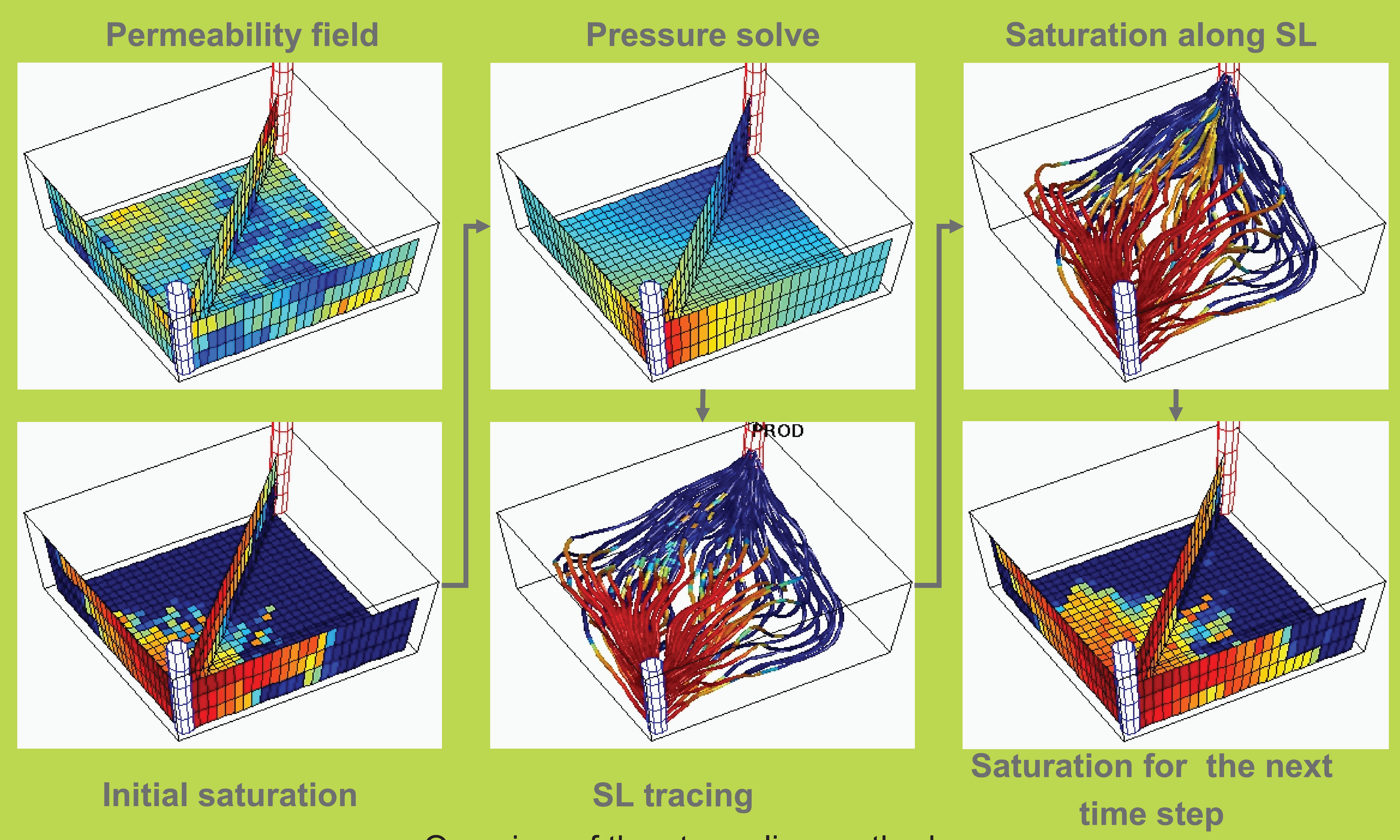
Sand-packed column injected with non-wetting fluid (oil dyed red).



Experimental Results showing the oil/water and gas/water trapping curves

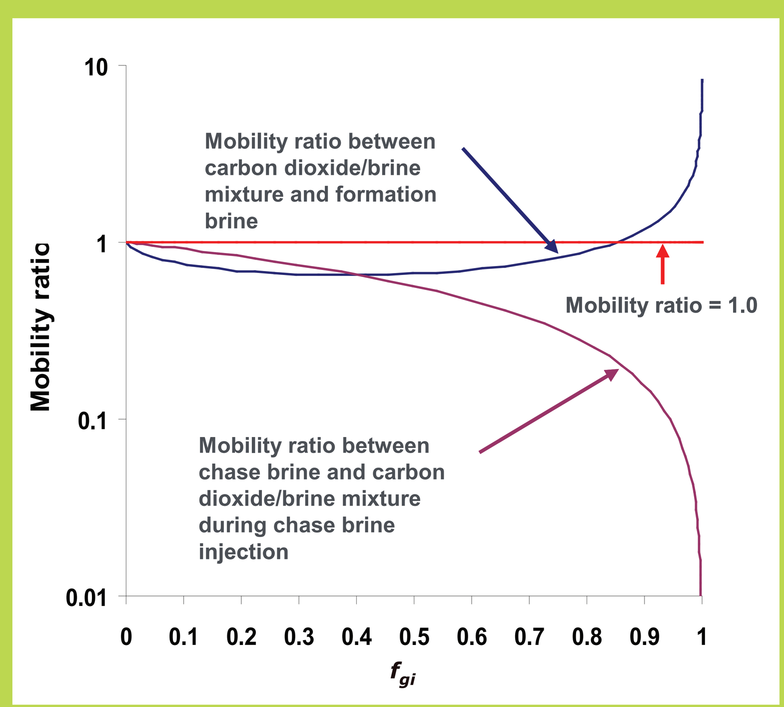
MODELLING TRAPPING EFFICIENCY

Design an injection strategy to maximise CO_2 storage capacity and efficiency on the field scale - incorporating experimental and pore scale modelling results. Streamline based simulator modified for this purpose.

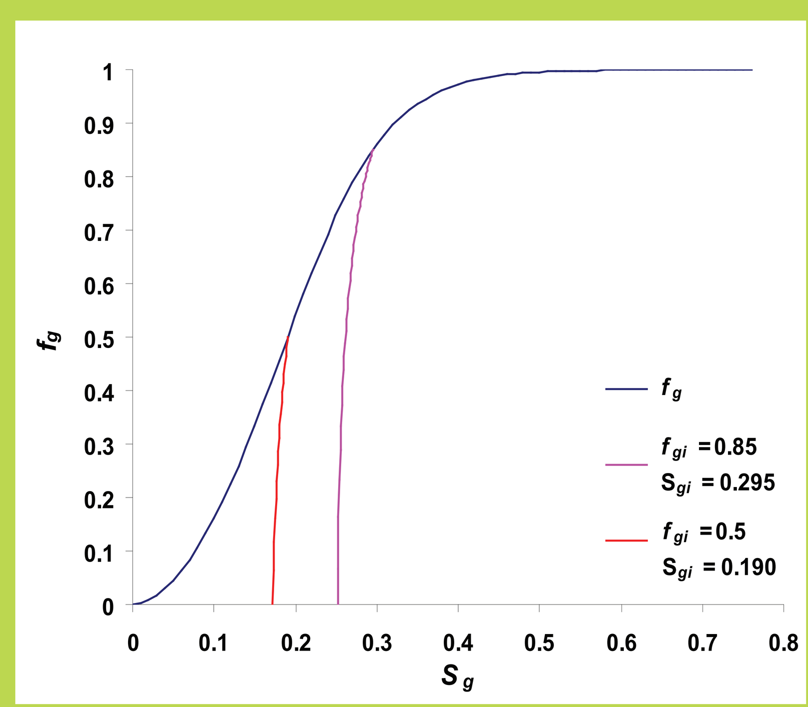


Overview of the streamline method

The mobility of the CO_2 front is controlled within the reservoir by injecting CO_2 in combination with water.



The ratio of the mobility of injected brine and CO_2 to the formation brine as a function of the injected CO_2-phase volume fraction, fgi.



The CO_2-phase fractional flow fg as a function of CO_2 (gas) saturation, Sg.

Once CO_2 injection ceases the reservoir is waterflooded. Due to the mobility contrast the waterflood front catches up with the CO_2. This process results in CO_2 being trapped on the pore scale as a residual phase.

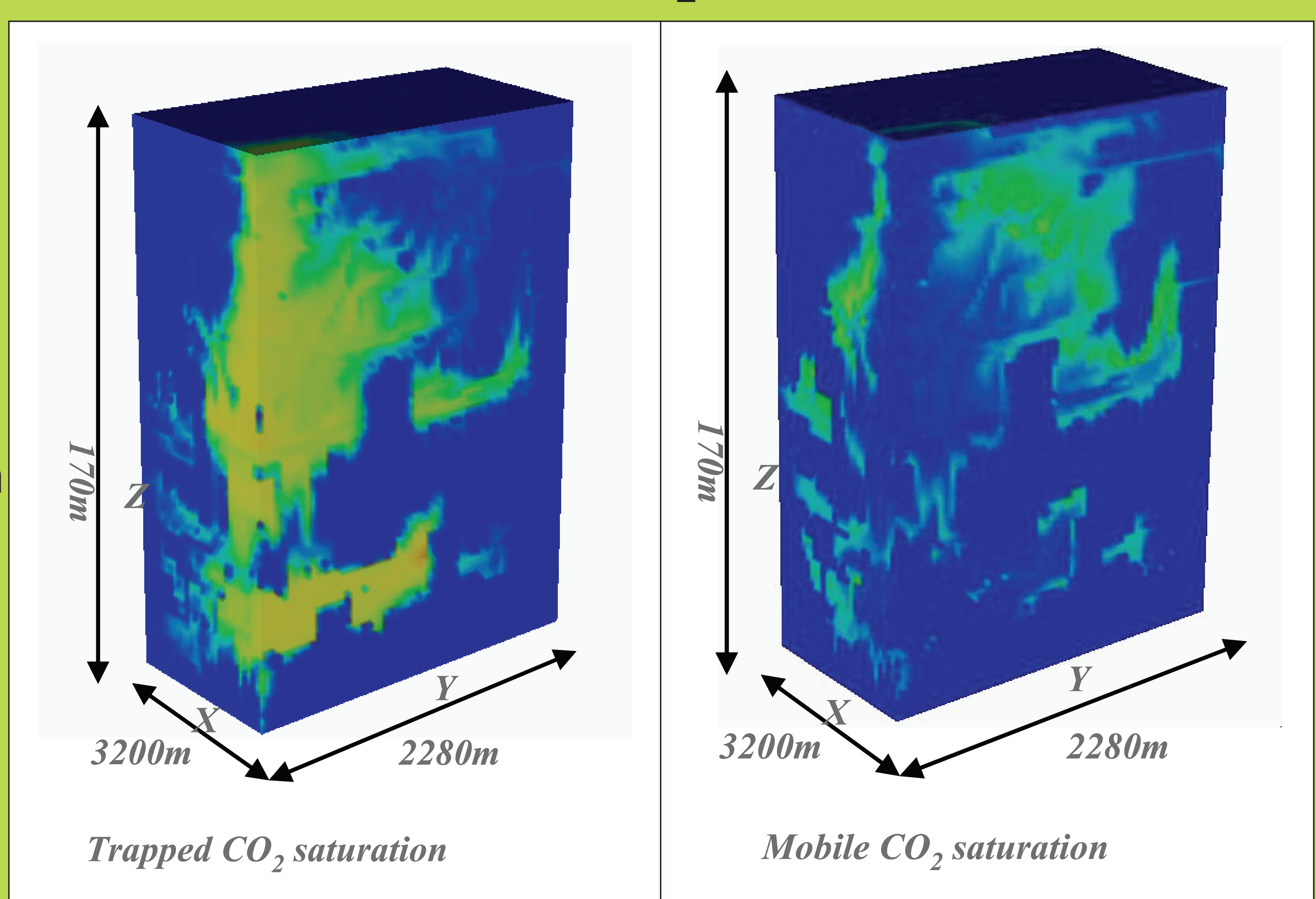
SPE 10 reservoir model, 1,200,000 grid cells (60 x 220 x 85), 7.8 Mt CO_2 injected.

Two years after chase water injection

Trapping efficiency = 95%

In other words 95% of the injected CO_2 is rendered immobile through capillary trapping or dissolution.

Only 5% of injected CO_2 is reliant upon hydrodynamic trapping below an impermeable cap rock.



Our work on the design of an injection strategy implies that we can safely store carbon dioxide deep underground.

ACKNOWLEDGMENTS

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