PHYSICAL PHENOMENA DURING CO_2 INJECTION: FROM LAB TO FIELD

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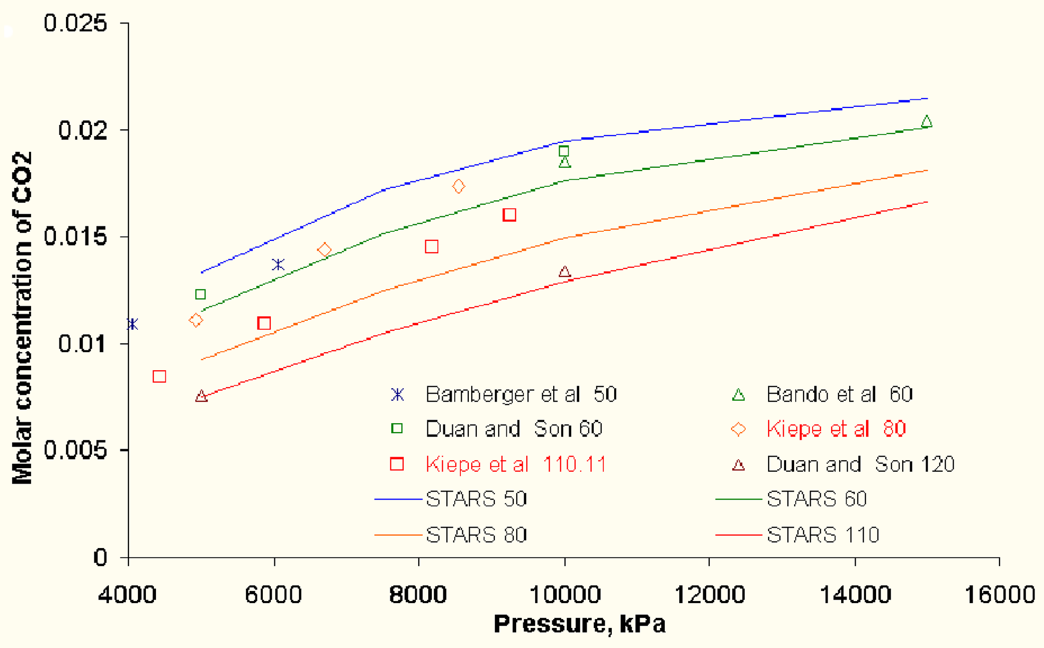
CO_2 DISSOLUTION

- Important trapping mechanism
- Dissolved CO_2 propagates together with aqueous phase not with gas phase
- CO_2 solubility well handled in modern reservoir simulation tools:



CO_2 solubility in water. Experimental data and STARS simulation

KEY FINDINGS

Preliminary simulations confirmed efficiency of CO_2 storage cites on NCS

Disregard for physical forces during simulation may cause significant errors in predicting CO_2 EOR or storage efficiency

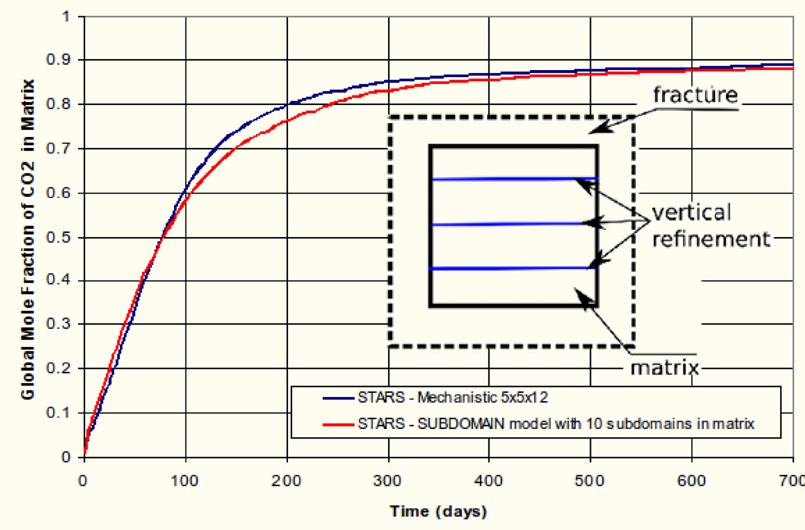
Knowledge, methods and tools from CO_2 EOR might be transferred to sequestration projects

An Open Source Code initiative was started together with Sintef / UiB / Success / Unifob to create a consistent and efficient full-physics simulator with source code available to researchers and engineers.

DIFFUSIVE & GRAVITY FORCES

Migration during sequestration period would be controlled by diffusion and gravity.

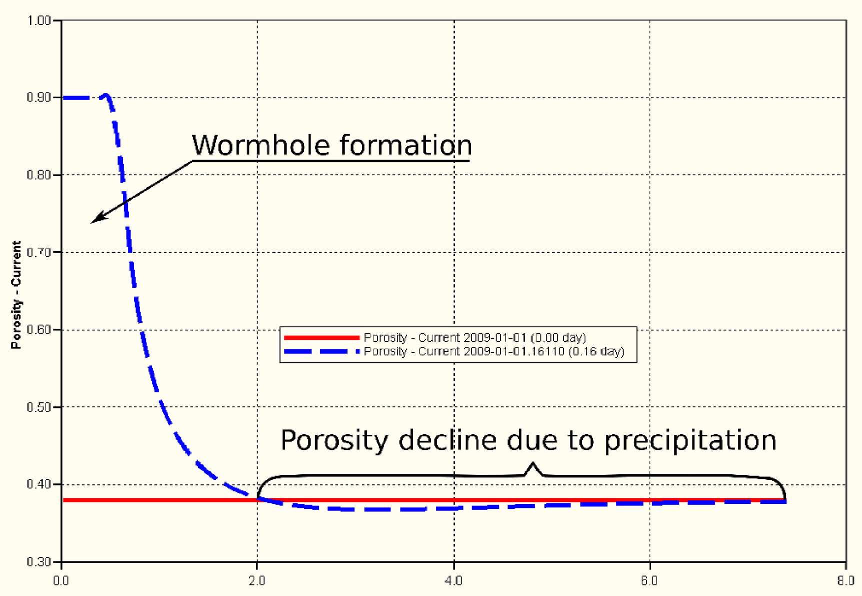
- Diffusive forces
  - Molecular Diffusion and Dispersion
  - Modern simulation tools have issues handling it in dual porosity environment
- Gravity
  - Might require special grid handling methods



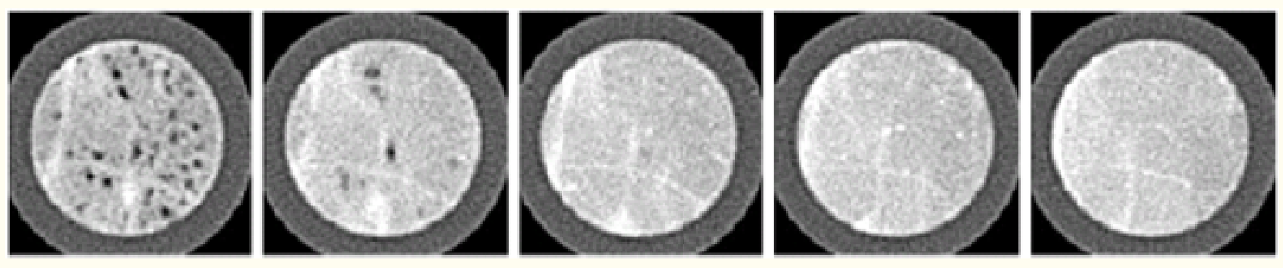
SUBDOMAIN grid and simulation results

INTERACTION WITH RESERVOIR ROCK

CT-scan core measurements in DTU showed that carbonated water creates up to 1cm long wormholes:



Porosity change after carbonated water injection.

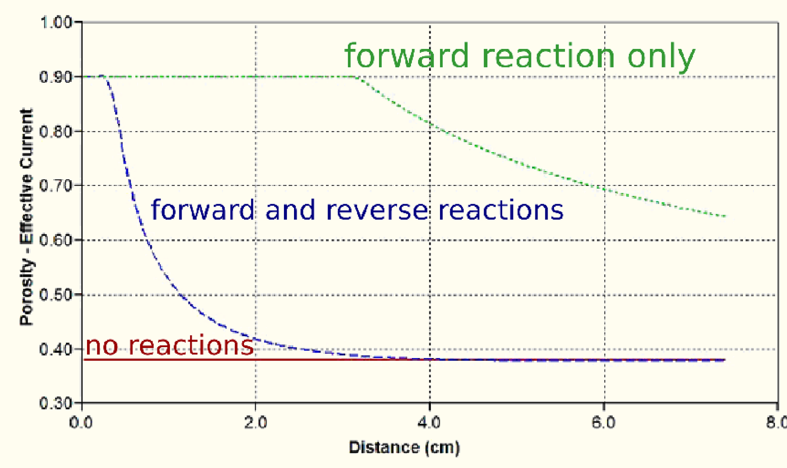


This happens due to chemical reaction with the rock.

$$CaCO_3(s) + CO_2(aq) + H_2O \rightleftharpoons Ca(HCO_3)_2$$

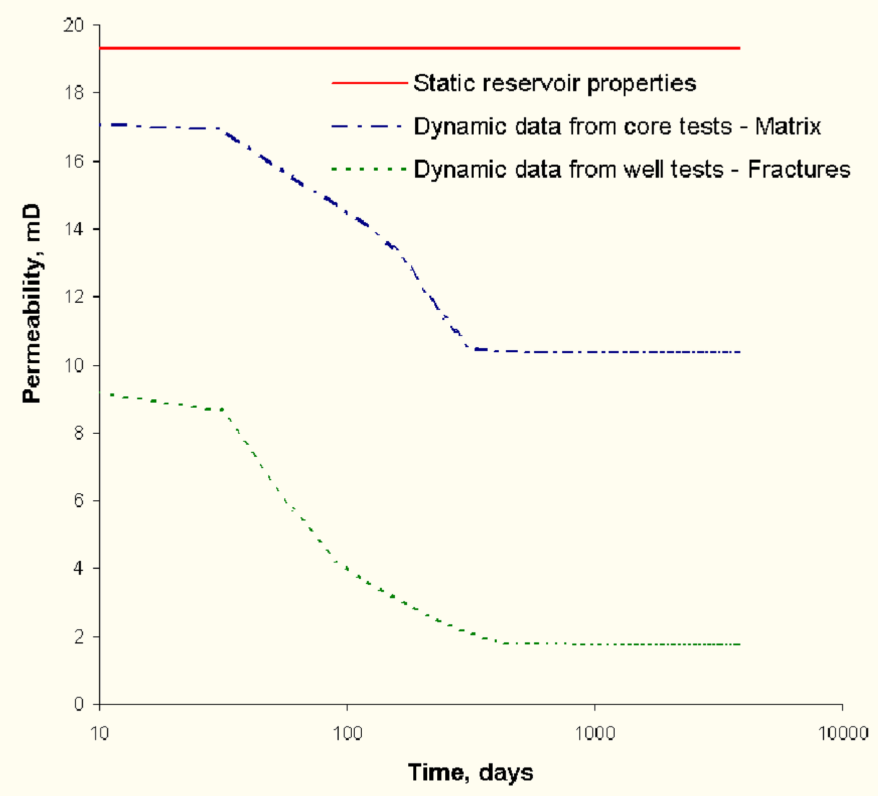
As wormholes grow it is natural to assume that injectivity increases, yet it *decreased* as a function of time due to reverse reaction and pore blockage due to $CaCO_3$ precipitation

How much dissolution / precipitation would occur during geological time?



Effect from forward and reverse reactions.

DYNAMIC RESERVOIR BEHAVIOUR



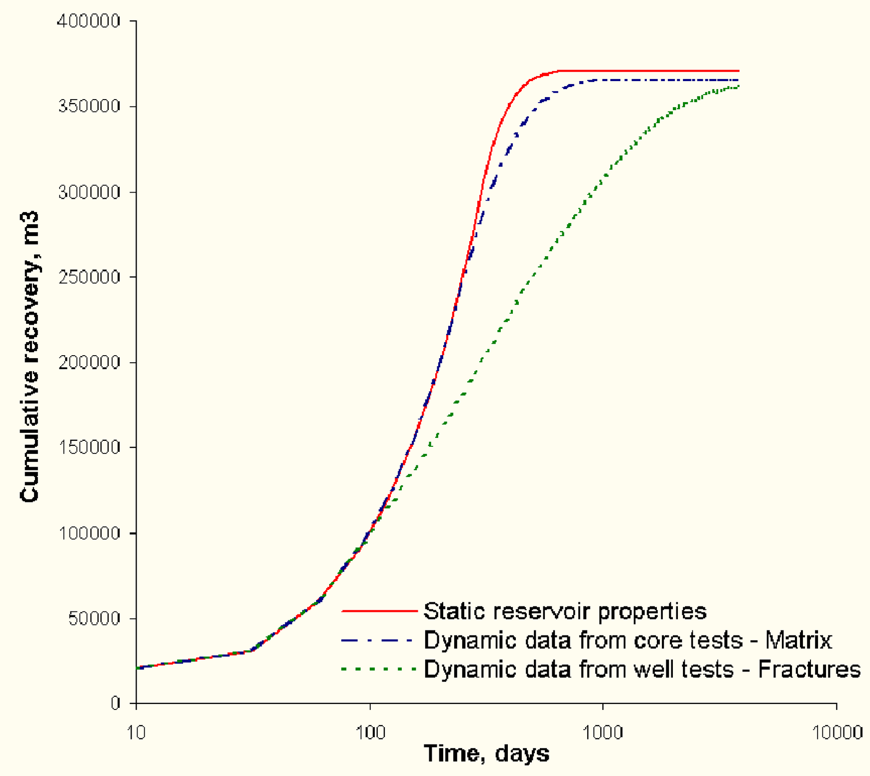
Permeability change with time due to pressure change

Both matrix and fracture porosity and permeability change under stress caused by injection or production

We evaluate dynamic behaviour through interpretation of core data, well tests and logs, production history, etc.

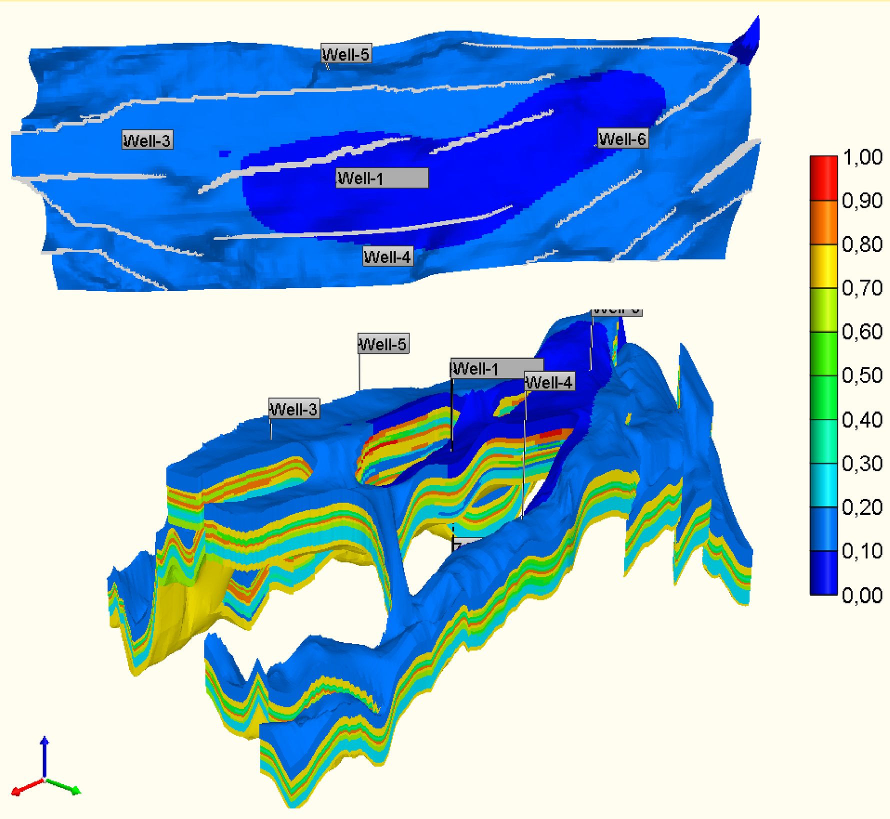
Injecting CO_2 may cause fractures and faults to open and increase migration through storage sites

This dynamic behaviour may also affect pore size distribution which governs capillary pressure and relative permeability curves



Production changes with time due to permeability change

MECHANISTIC STUDY



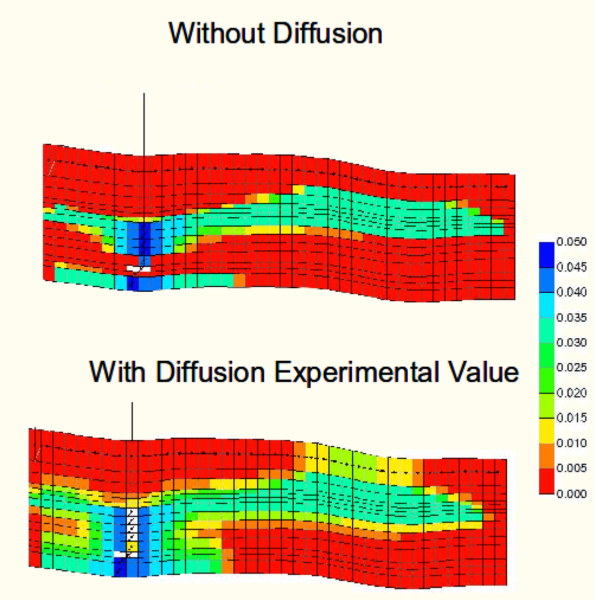
Segment from top and in 3D showing Net-To-Gross ratio

A typical segment of an actual Norwegian Continental Shelf faulted reservoir is chosen for the study

Twenty years of injection through 5 wells allowed to inject ca. 0.16 pore volumes (sm^3) of a segment without gas breakthrough to the top of the formation

Diffusion play significant role in CO_2 migration and leakage

Possibility of fault opening (through chemical reactions or pressure increase) was not evaluated but may significantly boost CO_2 migration upwards



CO_2 migration in aqueous phase

REFERENCES

Search for Berenblyum, Shchipanov, Surguchev: http://www.onepetro.com; http://www.earthdoc.org; Key papers:

Berenblyum, R., Calderon, G. and Surguchev, L. 2009 .Simulating CO_2 EOR Process: Numerical Investigation Based on the Experimental Results. SPE 126423 Presented at 2009 SPE International Conference on CO2 Capture, Storage, and Utilization held in San Diego, CA,2-4 November

Shchipanov A.A., Rusakov S.V. 2008 .Transient Pressure Well Test Analysis Based on Compressible Discrete Fracture Network // 11th European Conference on the Mathematics of Oil Recovery, Bergen, Norway, 8 - 11 September.