Impact of viscous fingering on CO_2 storage

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energi SIMULATION

BACKGROUND

Viscous fingering in porous media is an instability which occurs when a low-viscosity injected fluid displaces a much more viscous resident fluid, under miscible or immiscible conditions.

Viscous fingering is commonly observed in porous media, such as rocks or soils. In these settings, it can affect the movement of fluids in subsurface environments, including oil reservoirs, groundwater systems, and CO_2 sequestration.

Viscous fingering can impact the efficiency of CO_2 storage in geological formations. When CO_2 is injected into underground reservoirs, it is desirable for it to spread out and fill the available pore space uniformly. Viscous fingering can disrupt this process by causing CO_2 to channel through certain pathways, leaving large portions of the reservoir unfilled. This reduces the overall storage capacity and effectiveness of the storage site.

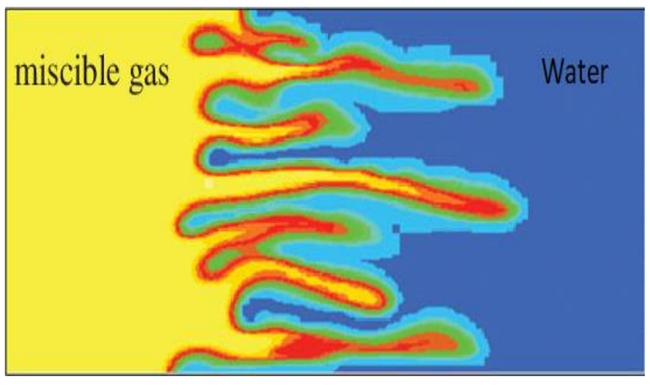
WHY / PURPOSE

It is important to investigate effect of viscous fingering in carbon capture and sequestration (CCS) projects since:

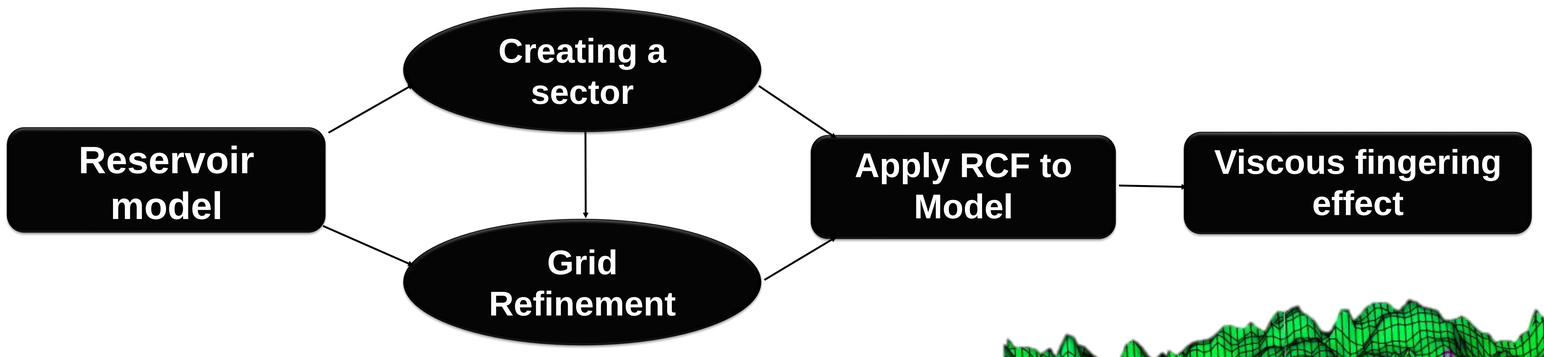
- This unstable CO_2-water interactions can affect different parameters in aquifer such as rate of CO_2 dissolution, average pressure, gas saturation profile, etc.

Purpose of this study includes:

- Investigation on different mechanisms in CO_2 storage such as: Structural trapping, Mineralization and Solubility trapping
- Investigate effects of different reservoir temperature and injection rate on CO_2 storage
- Future works will include modelling viscous fingering in CO_2 storage

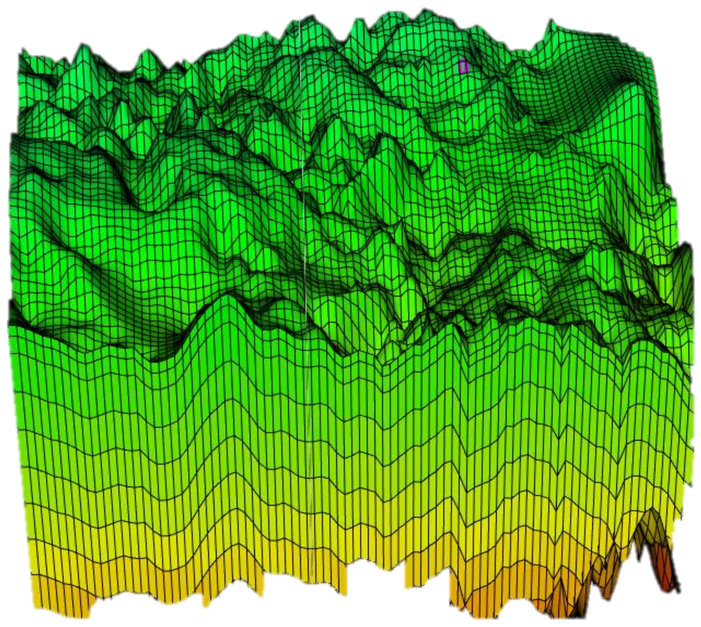


METHODOLOGY



- A sector of Utsira formation
- Initial conditions: 1310 psi @ 30 ℃
- Simulation time: 400 years
  50 years injection and observed parameters for 350 years
- 1 well at 2,000,000 m3/day injection rate
- Sector pore volume: 5.172× 10^{10} m^3

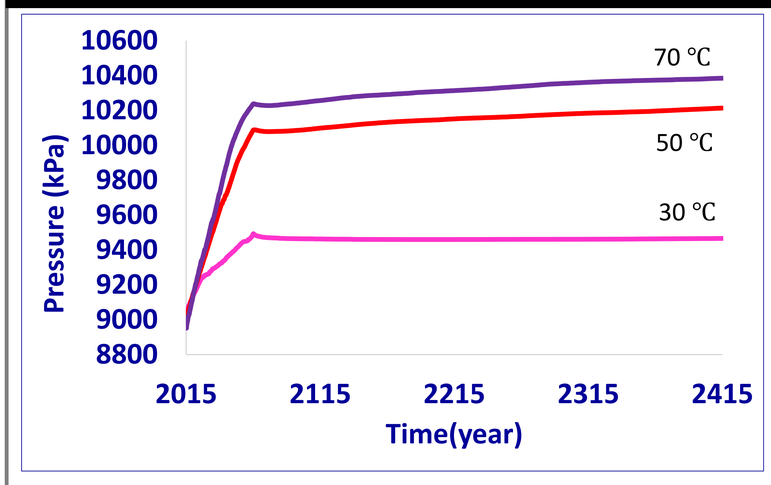
Model Parameters	Value
Number of grid blocks (I × J × K)	64 × 240 × 15
Porosity (%)	(0.3-0.34)
Horizontal permeability Kh (mD)	1000
Permeability anisotropy ratio (Kv/Kh)	1
Reference depth to aquifer top (m)	468.53
Initial reservoir pressure (kPa)	4680
Reservoir temperature (℃)	30

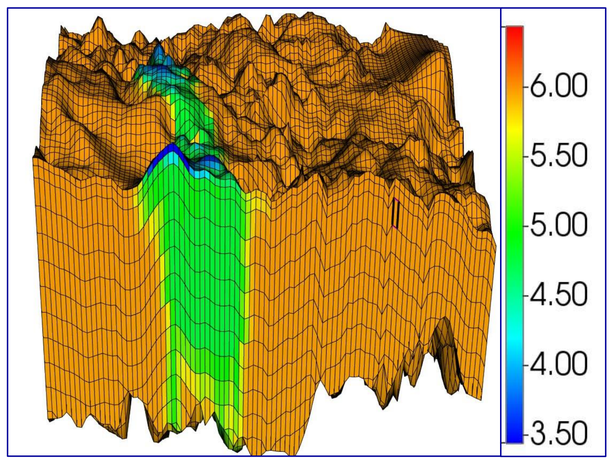


Temperature (℃) at rate of 2MM (m3/day)
30
50
70

Injection rates (m3/day) at 30 ℃
2,000,000
10,000,000

RESULTS



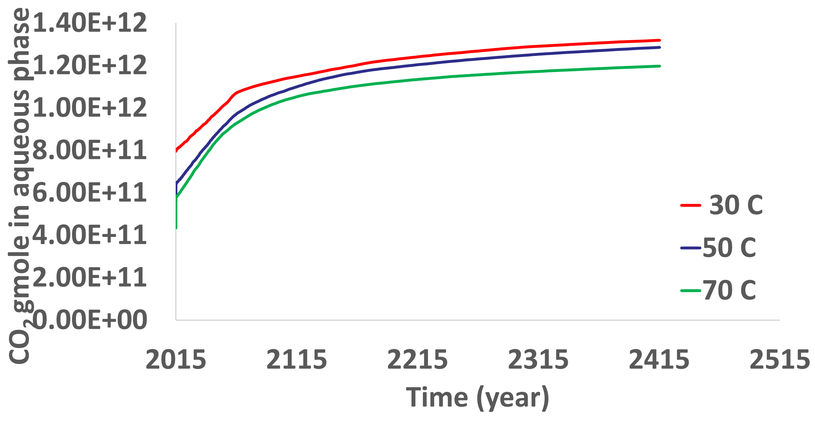


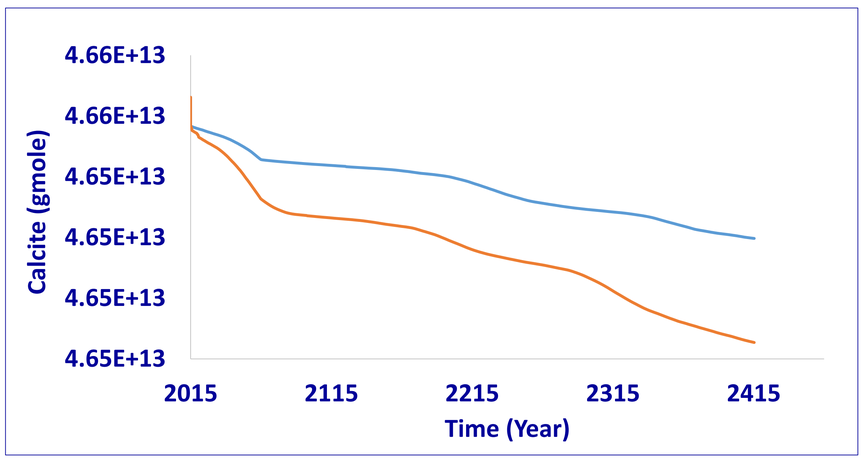
Decreasing of pH confirms dissolution of CO_2 in water

Increasing temperature → **Increasing pressure**

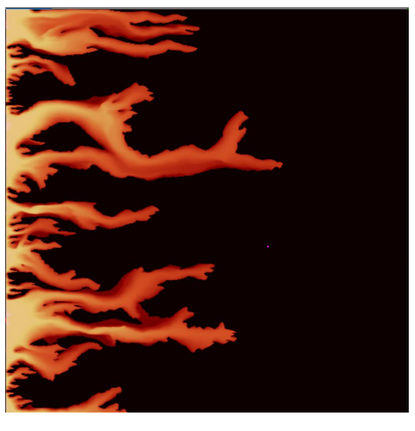
$$CO_2(aq) + H_2O \leftrightarrow H^+ + HCO_3^-$$

Solubility of CO_2 in water decreases with increase of reservoir temperature





Increasing injection rate → **Higher rate of Calcite dissolution**



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