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# Formation integrity evaluation for geosequestration of $CO_2$ in depleted petroleum reservoirs under cyclic stress conditions.

AMINAHO, E.

2023

ROBERT GORDON UNIVERSITY ABERDEEN

# Formation Integrity Evaluation for Geosequestration of $CO_2$ in Depleted Petroleum Reservoirs Under Cyclic Stress Conditions

## Sand Management Network Student Competition

29th November 2023

**Presented by:** Efenwengbe Aminaho (PhD Candidate)

# Introduction

**Low BI: < 0.1**
**Medium BI: 0.1 to 0.5**
**High BI: > 0.5**

Carbon dioxide ($CO_2$) geosequestration.

$CO_2$ stored in aquifers/depleted reservoirs.

**Geosequestration: cyclic and non-cyclic.**

**$CO_2$ conversion to Methanol or Hydrogen.**

**Cyclic process: sand management issues.**

**Formation integrity: Petrophysics & Brittleness.**

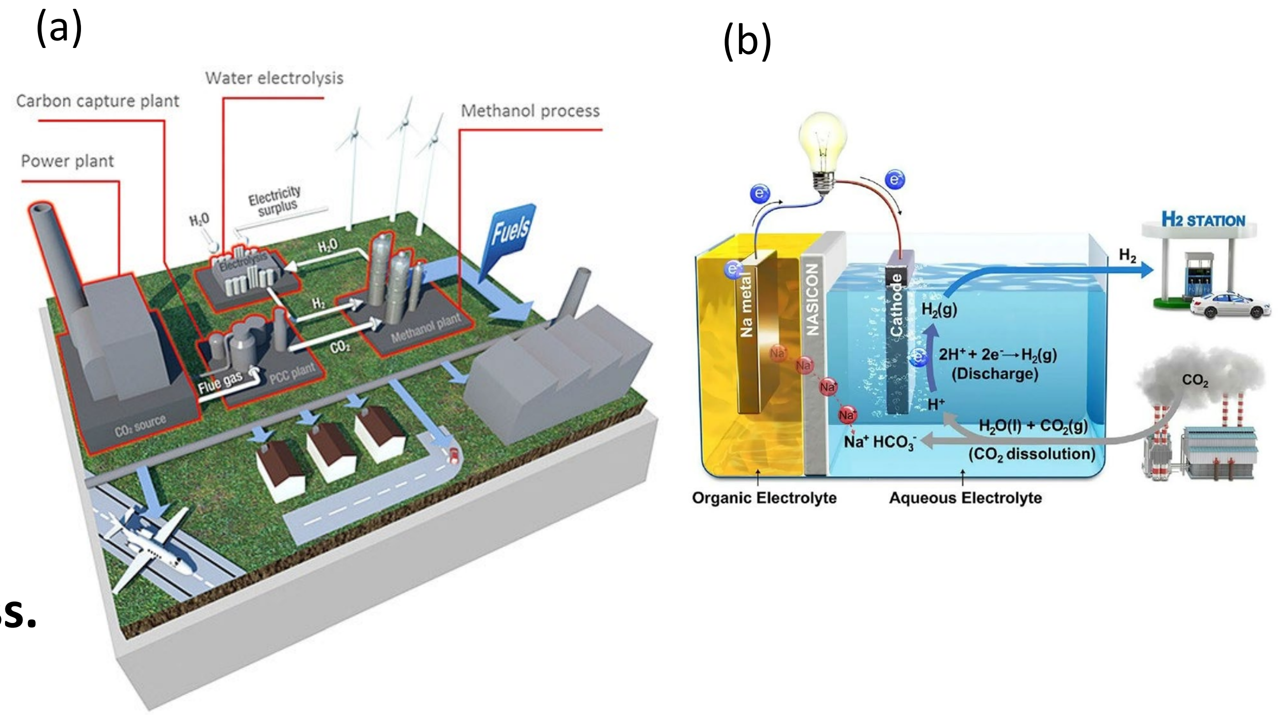



**Figure 1:** $CO_2$ conversion to (a) Methanol (Sánchez-Díaz, 2017) (b) Hydrogen (Kim et al., 2018).

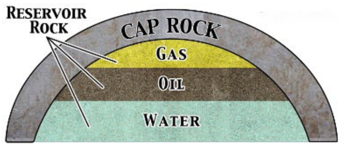



**Figure 2:** Petroleum reservoir-caprock structure.

# Aim & Objectives

✓ To evaluate formation integrity during cyclic injection and withdrawal of $CO_2$ gas stream.

- Evaluate the impact of impurities in the $CO_2$ gas stream on the petrophysics and brittleness of reservoir and caprock.

- Identify possible sand management and wellbore instability issues during cyclic withdrawal of $CO_2$.

# Methodology

## Mathematical model and numerical simulations

Mathematical model developed:

$$BI_{bm} = \frac{\frac{v_Q \overline{M}_Q}{\overline{V}_Q} + \frac{0.49 v_F \overline{M}_F}{\overline{V}_F} + \frac{0.51 v_C \overline{M}_C}{\overline{V}_C} + \frac{0.44 v_D \overline{M}_D}{\overline{V}_D}}{\sum_{i=1}^{nm} \frac{v_i \overline{M}_i}{\overline{V}_i}}$$

$\overline{M}$ - Molecular weight [g/mol]
$\overline{V}$ - Molar volume [$m^3$/mol]
$v$ - Volume fraction
BI - Brittleness index

- Fluid ratio: 97.5 mol% $CO_2$ : 2.5 mol% impurity.
- Impurities: $H_2S$ and $SO_2$.

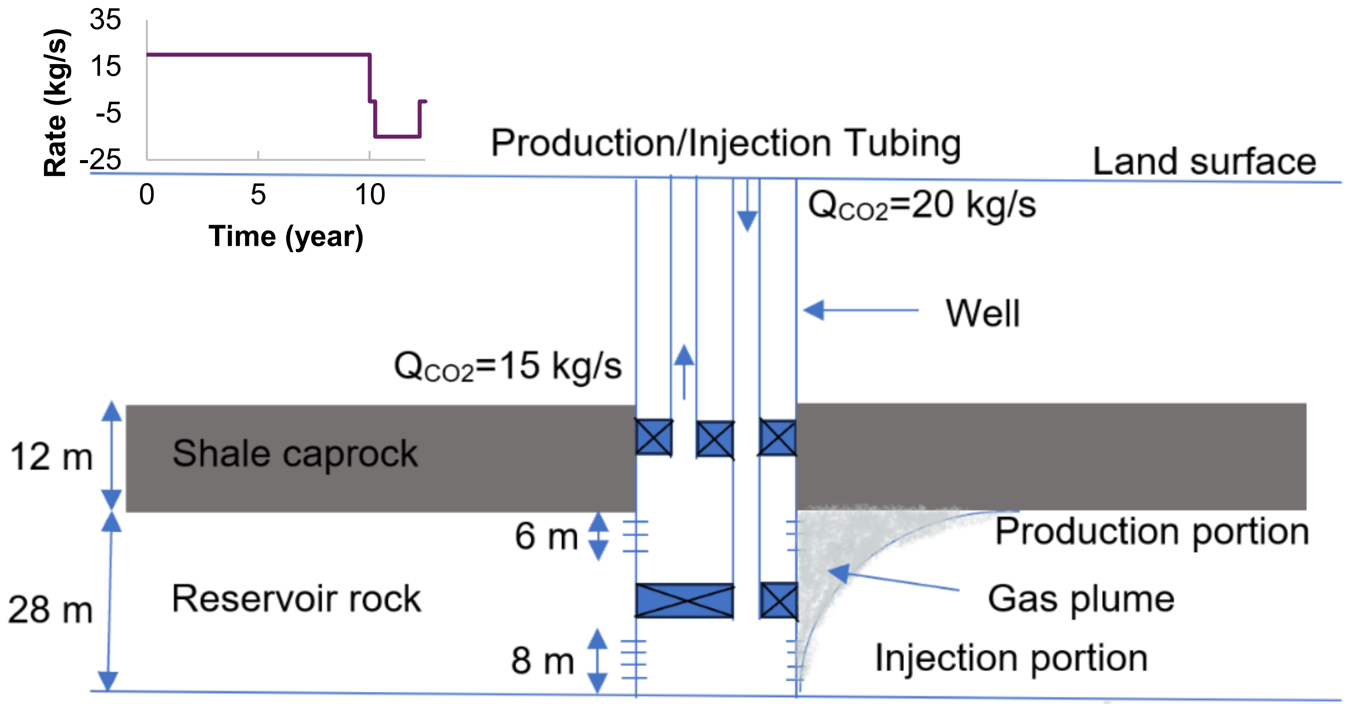
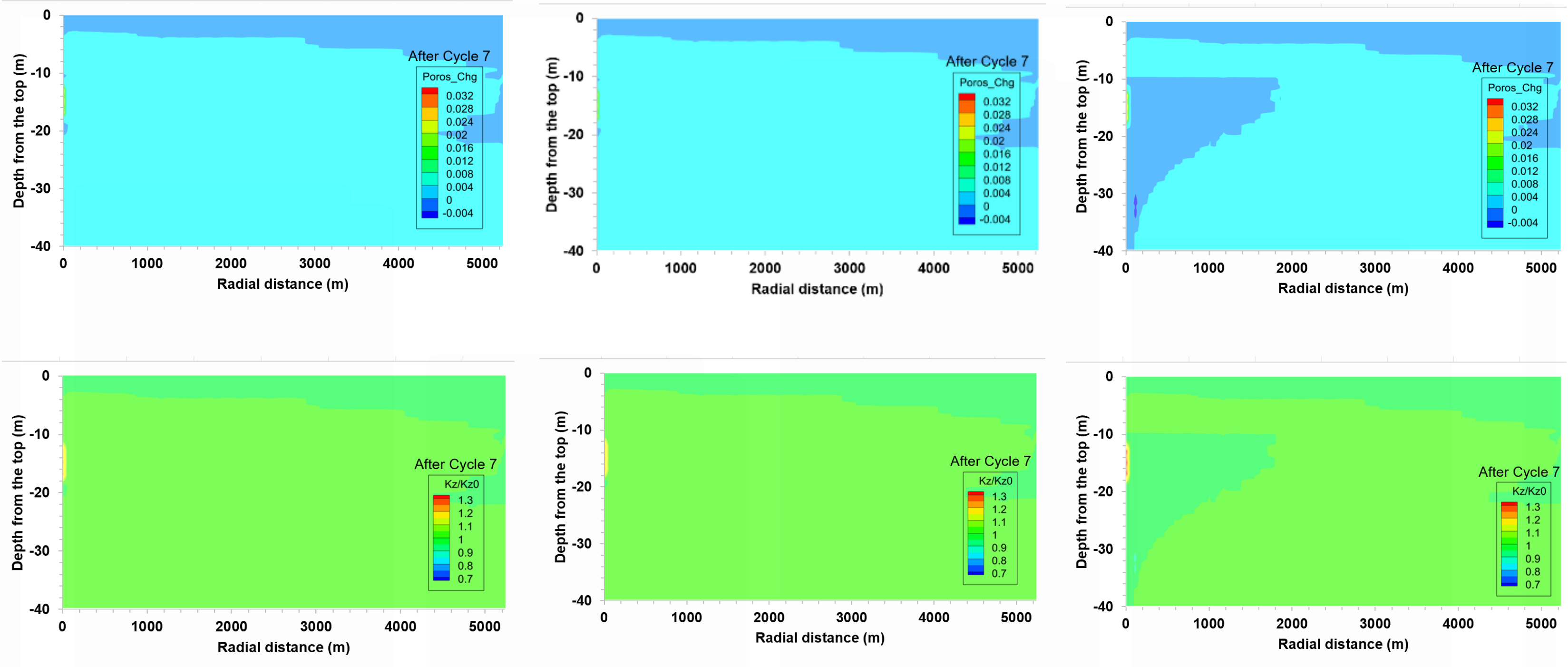



**Figure 3:** A 2-D radial flow model for cyclic injection and withdrawal of $CO_2$.

# Results & Discussion




(a) $CO_2$ alone case (b) $CO_2$-$H_2S$ case (c) $CO_2$-$SO_2$ case

**Figure 4:** Porosity change and permeability ratio in the sandstone reservoir and shale caprock.

- Notable increase in porosity and permeability at the production interval close to the wellbore.

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# Results & Discussion

**Table 1:** Percentage change in porosity and permeability of the reservoir and caprock.

| Formation type | Petrophysics | After cycle 7 | | |
|---|---|---|---|---|
| | | $CO_2$ | $CO_2$-$H_2S$ | $CO_2$-$SO_2$ |
| **Shale caprock** | Change in porosity (%) | -0.03 to 0.19 | -0.03 to 0.21 | -0.30 to 0.13 |
| | Change in permeability (%) | -0.10 to 0.59 | -0.10 to 0.66 | -0.92 to 0.40 |
| **Sandstone reservoir** | Change in porosity (%) | -1.56 to 5.98 | -1.54 to 5.97 | -4.42 to 7.86 |
| | Change in permeability (%) | -6.12 to 26.70 | -6.06 to 26.68 | -16.54 to 36.29 |

- Slight decrease in porosity and permeability below the production perforation interval – deposition of fines.
- Decrease in porosity and permeability for the $CO_2$-$SO_2$ case mainly due to the precipitation of anhydrite.

# Results & Discussion

**Table 2:** Brittleness index of the formation before and after $CO_2$ geosequestration.

| Formation type | Brittleness index | Before sequestration, t=0 | | | After cycle 7 | | |
|---|---|---|---|---|---|---|---|
| | | $CO_2$ | $CO_2$-$H_2S$ | $CO_2$-$SO_2$ | $CO_2$ | $CO_2$-$H_2S$ | $CO_2$-$SO_2$ |
| Shale caprock | $BI_{bm}$ | 0.0377 | | | 0.0375 to 0.0377 | | 0.0373 to 0.0377 |
| Sandstone reservoir | $BI_{bm}$ | 0.4593 | | | 0.4582 to 0.4594 | | 0.4433 to 0.4593 |

- Change in brittleness index (BI) in the reservoir is negligible, except for the $CO_2$-$SO_2$ case.
- In the reservoir, close to the production perforation interval, BI decreases slightly.
- Slight increase in BI (to 0.4594) below the production perforation interval – confirms the deposition of brittle minerals.

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# Conclusions & Recommendations

- More dissolution of minerals at the interval open to production in the reservoir.
- The BI of sandstone reservoir and shale caprock decreases during $CO_2$ geosequestration.
- **Sand management practices (e.g., sand screens) are required to minimise fines migration.**
- Optimum $CO_2$ withdrawal rate/bottom hole pressure to minimise wellbore instability issues.

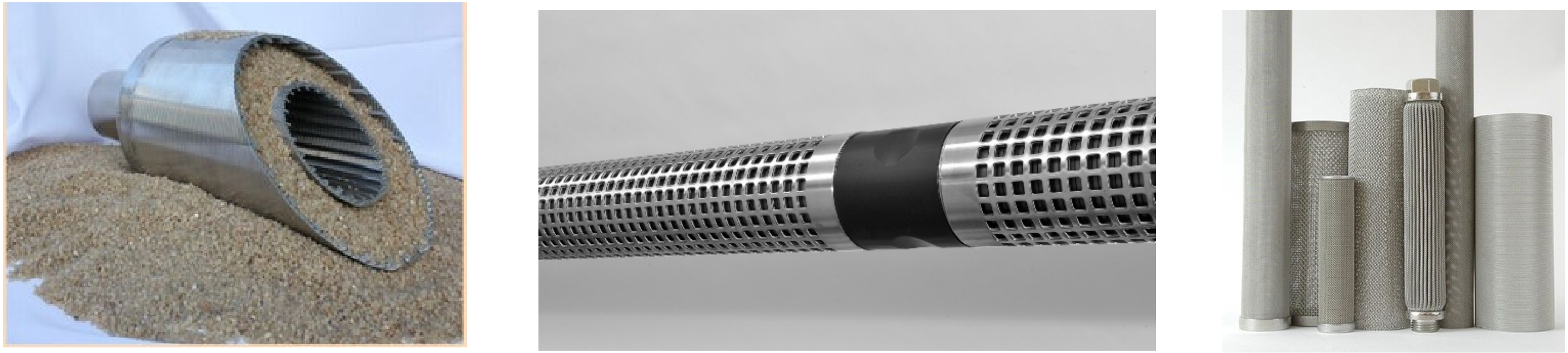

**Figure 5:** Sand screens

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# THANK YOU!

**Any Questions?**