# Reusing depleted oil and gas reservoirs for CO2 storage: Thermal cyclicity impact on mechanical and transport properties of host and seal formations in the near-wellbore area

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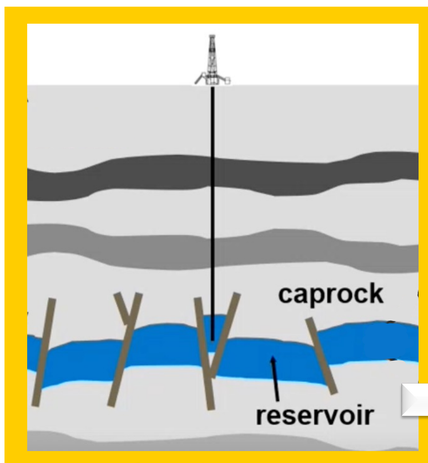
**Abstract**
The present study aims to investigate the impact of temperature and pressure cycling on the properties of the reservoir and caprock in the near-wellbore area during $CO_2$ storage operations. To achieve this objective, an experimental approach was employed using representative sandstone (Bleurswiller; 24% porosity). The preliminary results of the study has indicated that the freezing/thawing cycles caused a permanent reduction in the bulk volume and permeability, while no significant changes were observed in material strength and stiffness.

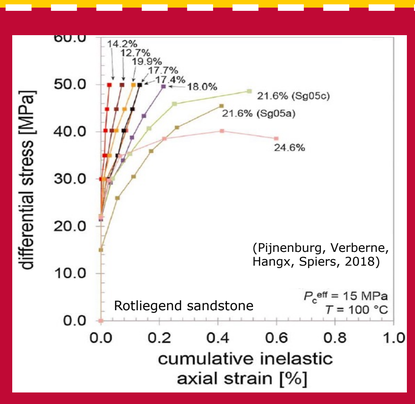



## Introduction

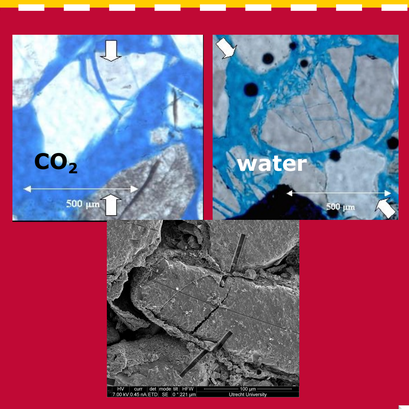
CO2 injection in the low pressure depleted reservoirs:

- Joule-Thomson cooling
- Re-pressurization

- Thermal fracturing, hydrates generation, framework rearrangement, and microcracks growth[1,2,3].
- dT/dt, fluid, saturation level, ΔT, number of cycles, confining pressure



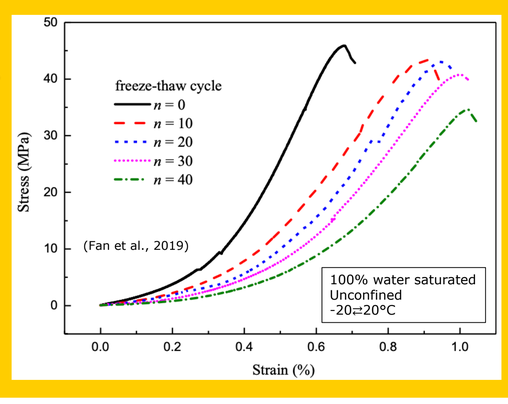

- High Ø → ~50% permanent strain
- Loading history
- Loading rate




$CO_2$ presence:

- Inhibits crack growth
- Swelling/sorption

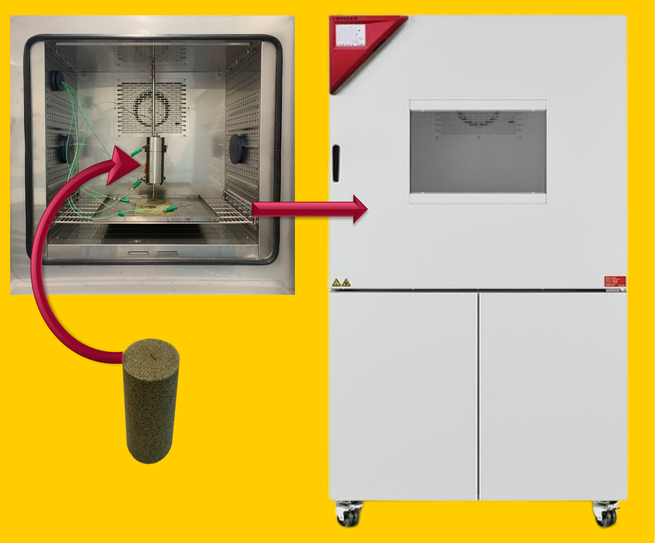
- Prior experiments: significant impact of unconfined freezing/thawing cyclicity on mechanical properties, primarily during the initial 20 freeze-thaw cycles[3,6].
- Numerical researches: insignificant thermal effect when effective in-situ horizontal stresses exceed 10 MPa[7].



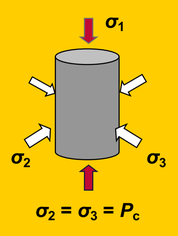

## Methodology

### 1.Freezing-thawing experiments

- Analogue sandstone: Bleurswiller (ø=24%)
- Fully saturated: 5% (0.85 M) brine
- dT/dt ≃ 0.3 °C/min
- ΔT : 100 ⟶ -20°C or 100 ⟶ 5°C
- $P_c^{eff}$ : 20MPa or 5MPa ($P_p$= 5MPa)
- Number of F/T cycles: single cooling/freezing cycle and 20 cycles



### 2. Permeability measurement and triaxial experiment




### 3. Microstructural analysis → Constitutive equations

## Results

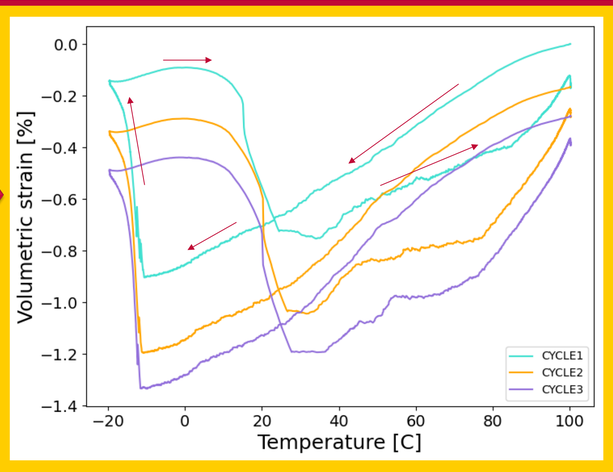



**Figure 1.** **Bulk volumetric strain versus T for the first three freezing/thawing cycles of a 20-cycle experiment.**

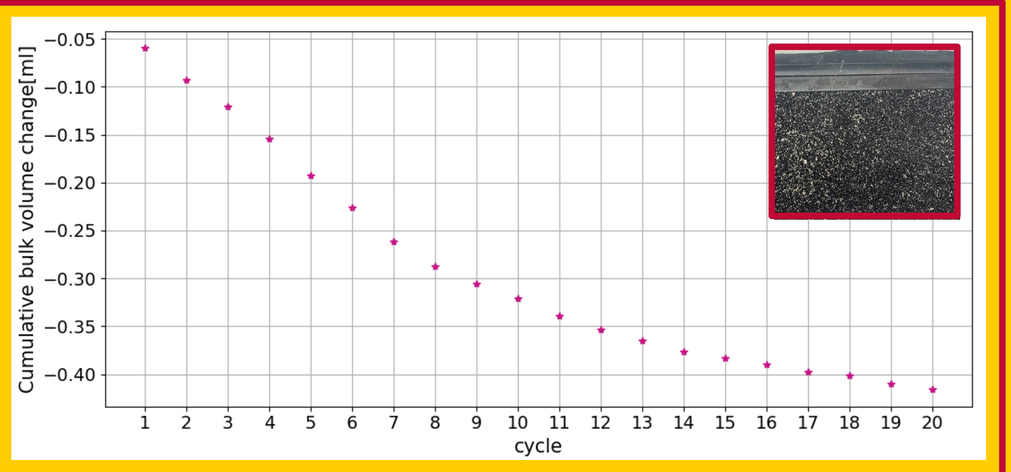



**Figure 2.** **Cumulative bulk volume reduction during 20 freezing/thawing cycles**

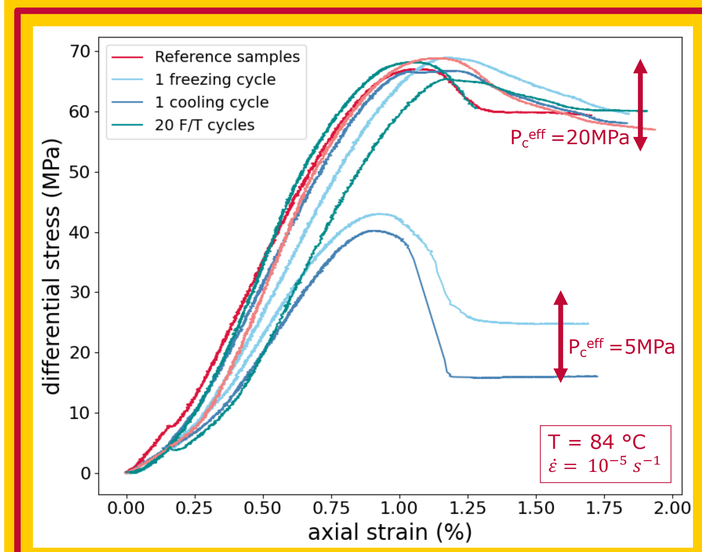



**Figure 3.** **Differential stress vs. axial strain curves**

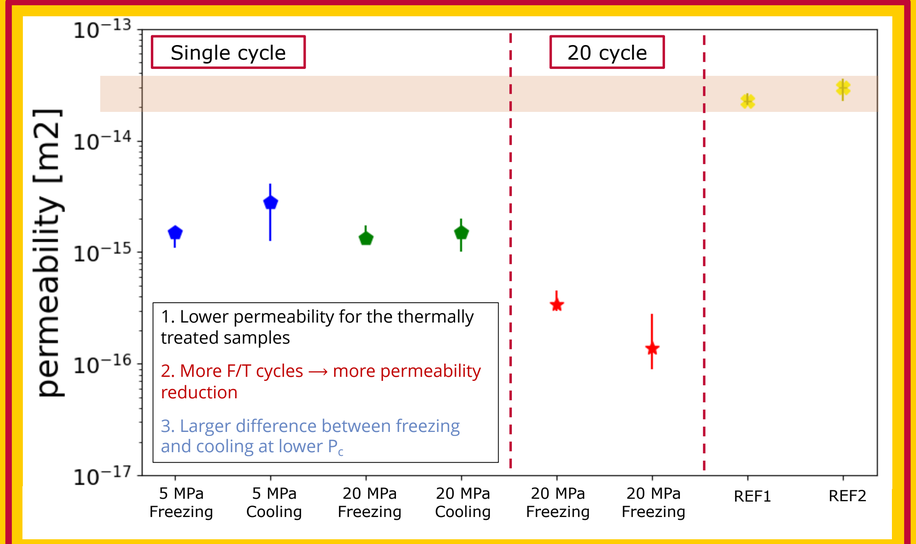



**Figure 4.** **water permeability range for all experiments**

## Implication and outlook

Our main observations after applying F/T cycles

1. Permanent bulk volume reduction (0.1% for one cycle, ~0.5% for 20 cycles)
2. Permeability reduction: more at lower $P_c$
3. No change in material's strength and stiffness

- ➢Permeability reduction ➜ increase in pressure gradients ➜ Joule-Thomson cooling ⇧
- ➢Microstructural analysis
- ➢Investigating the impact of following parameters:
  - a. Saturation level
  - b. Saturating fluid
  - c. Cooling/heating rate
  - d. Number of F/T cylces
  - e. ΔT
  - f. Confining pressure

**References**

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