Effect of CO_2 injection on chalk properties

- are Danish chalk reservoirs suitable for CO_2 storage?

Influence of CO_2 injection on mechanical properties of chalk

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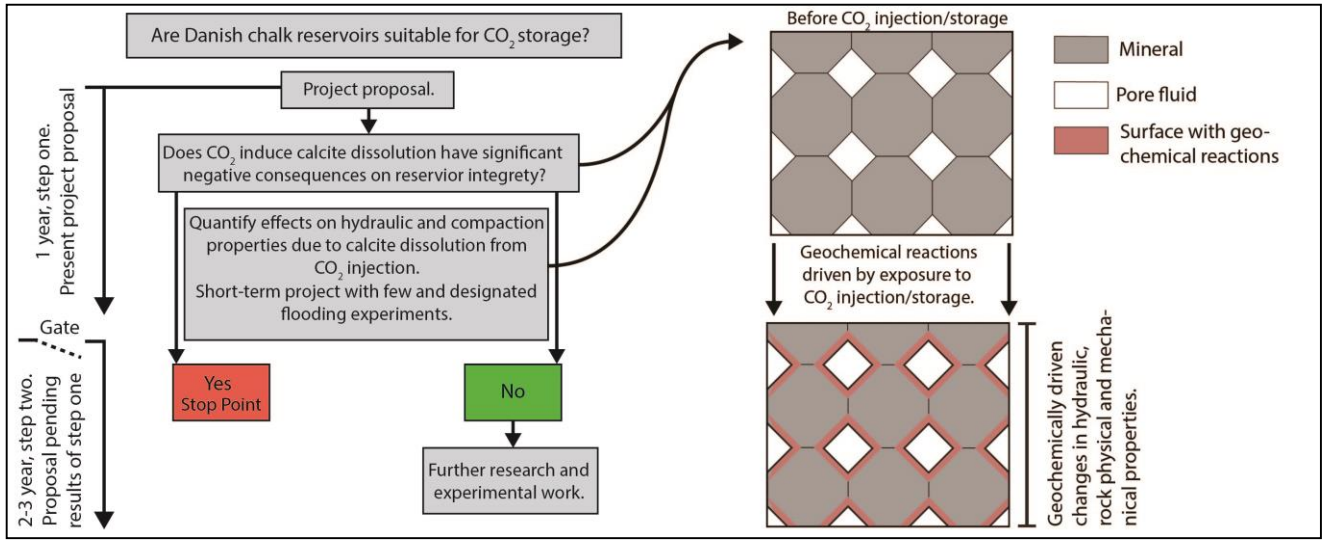
- are Danish chalk reservoirs suitable for CO_2 storage?

- Project overview
  - Geochemical analysis
  - Rock physical analysis
  - Geomechanical analysis
- 1 year project



- Project objective
  - Quantify and describe effects on hydraulic and compaction properties due to calcite dissolution from CO_2 injection and storage in Danish chalk reservoirs.

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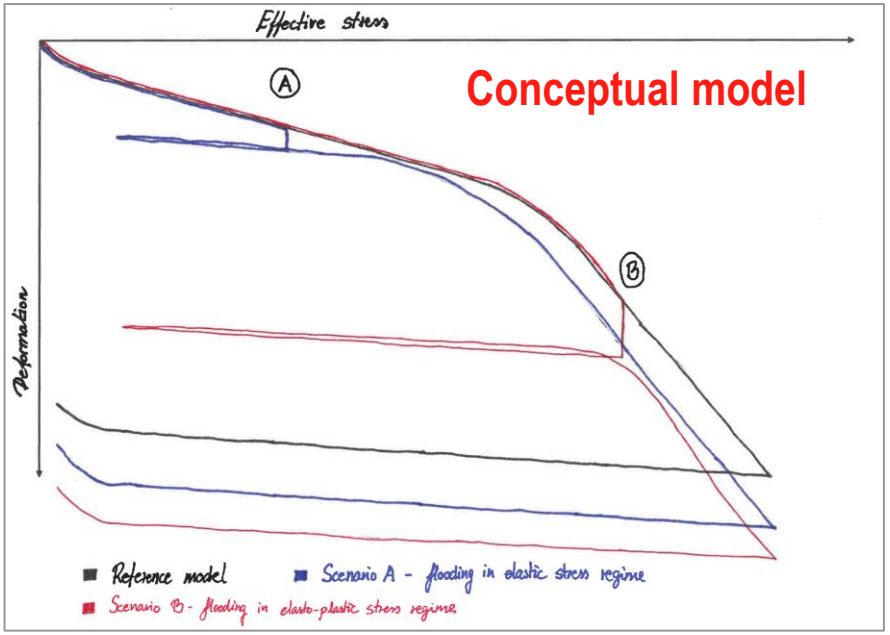
- Geomechanical experiments
  - Combined SC.CO_2 / WAG flooding phases and geomechanical testing – mimic the geochemical flooding phases performed at GEUS
    - 5 geomechanical experiments
      - 1 reference test – no flooding
      - 2 tests w. flooding in elastic stress
        - 1 x SC.CO_2 and 1 x WAG w. 3 cycles
      - 2 tests w. flooding in elasto-plastic stress
        - 1 x SC.CO_2 and 1 x WAG w. 3 cycles



- How does the mechanical properties of the chalk behave when exposed to super-critical CO_2 and WAG injection cycles?

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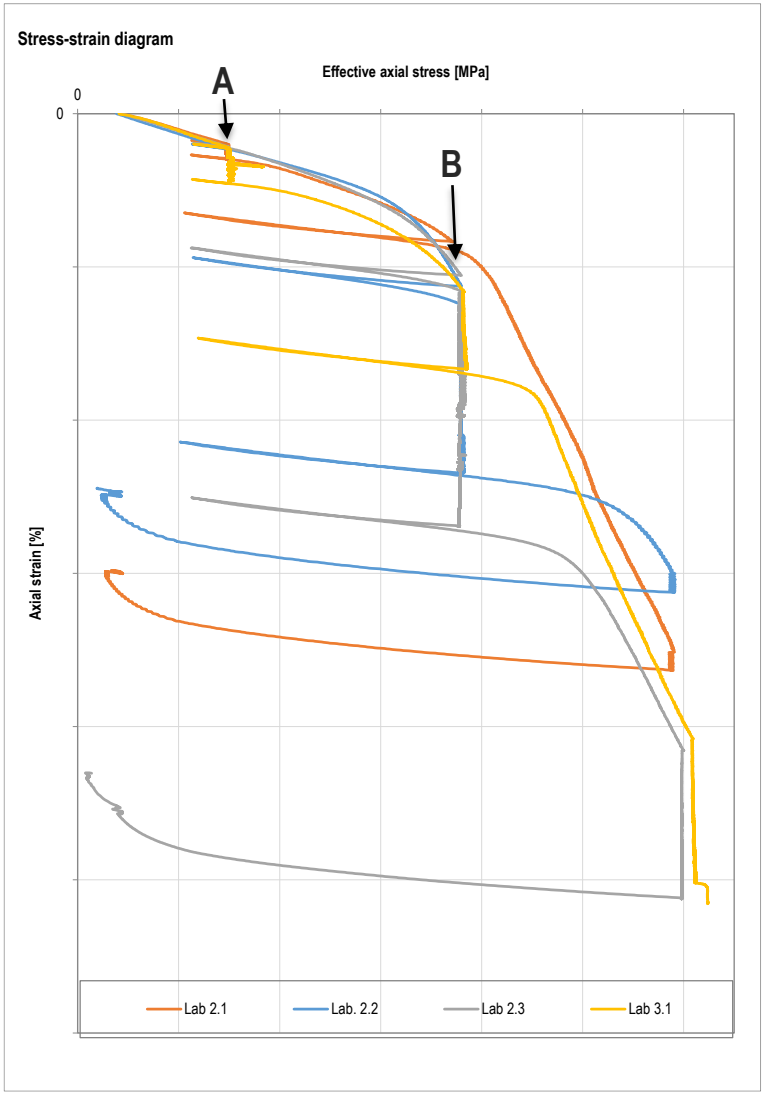
- are Danish chalk reservoirs suitable for CO_2 storage?

- Geomechanical experiments
  - 2.1: SC.CO_2 flood @ 15MPa eff. axial stress
  - 2.2 : SC.CO_2 flood @ 38MPa eff. axial stress
  - 2.3: 3xWAG @ 38MPa eff. axial stress
  - 3.1: 3xWAG @ 15MPa eff. axial stress
- Geomechanical analysis
  - Strength
    - Evaluate the effect of SC.CO_2 and WAG flooding @ 15MPa vs. Lab. 2.2 and Lab. 2.3 which were flooded @ 38MPa
  - Stiffness
    - Evaluate stiffness change due to SC.CO_2 and WAG flooding from primary and unloading/reloading phases
  - Additional deformation due to CO_2 flooding / chalk dissolution
    - 2.1 vs. 2.2 & 2.3 vs. 3.1: Additional strain is observed at higher eff. stress?
    - 2.1 vs. 3.1 & 2.2 vs. 2.3: Additional strain is observed from WAG phases?



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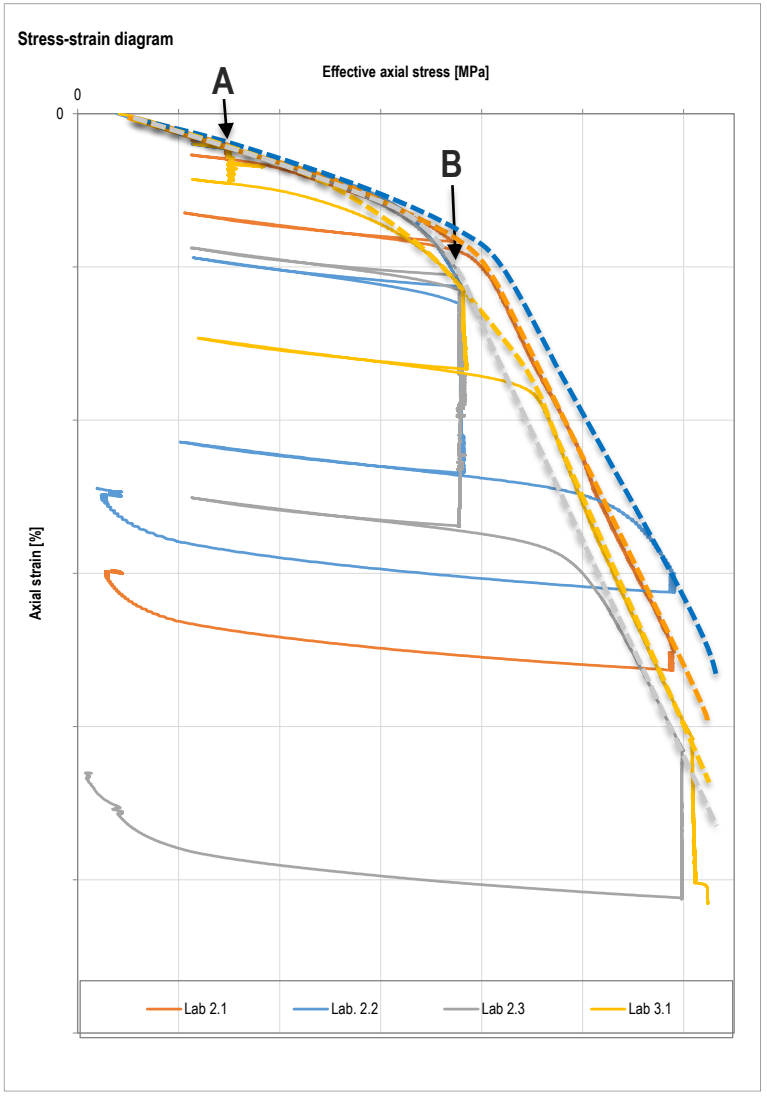
- are Danish chalk reservoirs suitable for CO_2 storage?

- Geomechanical analysis – observations / early indications
  - *No detailed analysis of the results is performed yet. Only rough observations.*
  - Strength
    - Equal strength for 2.2 and 2.3 which experienced no flooding below pore collapse
    - Higher strength for 2.1 which were flooding only with SC.CO2
    - Minor strength effect for 3.1 which were experienced 3 WAG phases @ 15MPa
  - Stiffness
    - No observed change
  - Additional deformation due to CO_2 flooding / chalk dissolution
    - Observation of reloading phase for 2.2 and 2.3 compared to 2.1 and 3.1
    - 2.1 vs. 2.2 & 2.3 vs. 3.1: Additional strain is observed at higher eff. Stress?
    - 2.1 vs. 3.1 & 2.2 vs. 2.3: Additional strain is observed from WAG phases?



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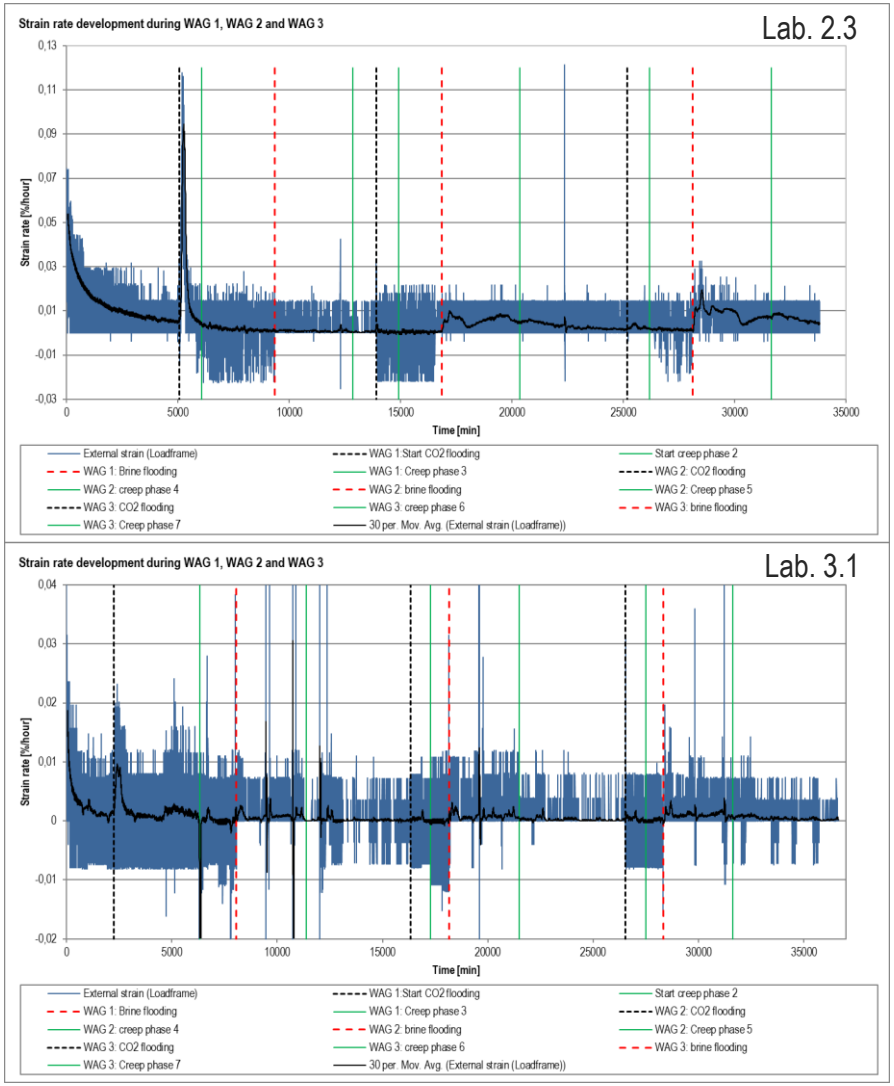
- are Danish chalk reservoirs suitable for CO_2 storage?

- Geomechanical analysis – observations / early indications
  - *No detailed analysis of the results is performed yet. Only rough observations.*
  - Additional deformation due to CO_2 flooding / chalk dissolution
    - 2.3: 3xWAG @ 38MPa eff. axial stress
    - 3.1: 3xWAG @ 15MPa eff. axial stress
    - Significant difference in deformation rate during WAG phases @ 15MPa and 38MPa



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- Evaluations
  - WAG proces is not used in field application
    - However, WAG is a suitable laboratory proces to evaluate how the chalk properties change when exposed to CO2.
  - Need to investigate the scenarios taking place near wellbore and at boundaries between fluids
  - Will there be equilibrium and how fast?
  - How do our evaluations change if/when
    - The porosity increase
    - Specific surface area change
    - Mineralogy change
    - CO_2 is not clean