RETURN - Reusing depleted oil and gas fields for CO_2 sequestration

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7th ACT Knowledge Sharing Workshop
4-5th October 2023
Paris, France

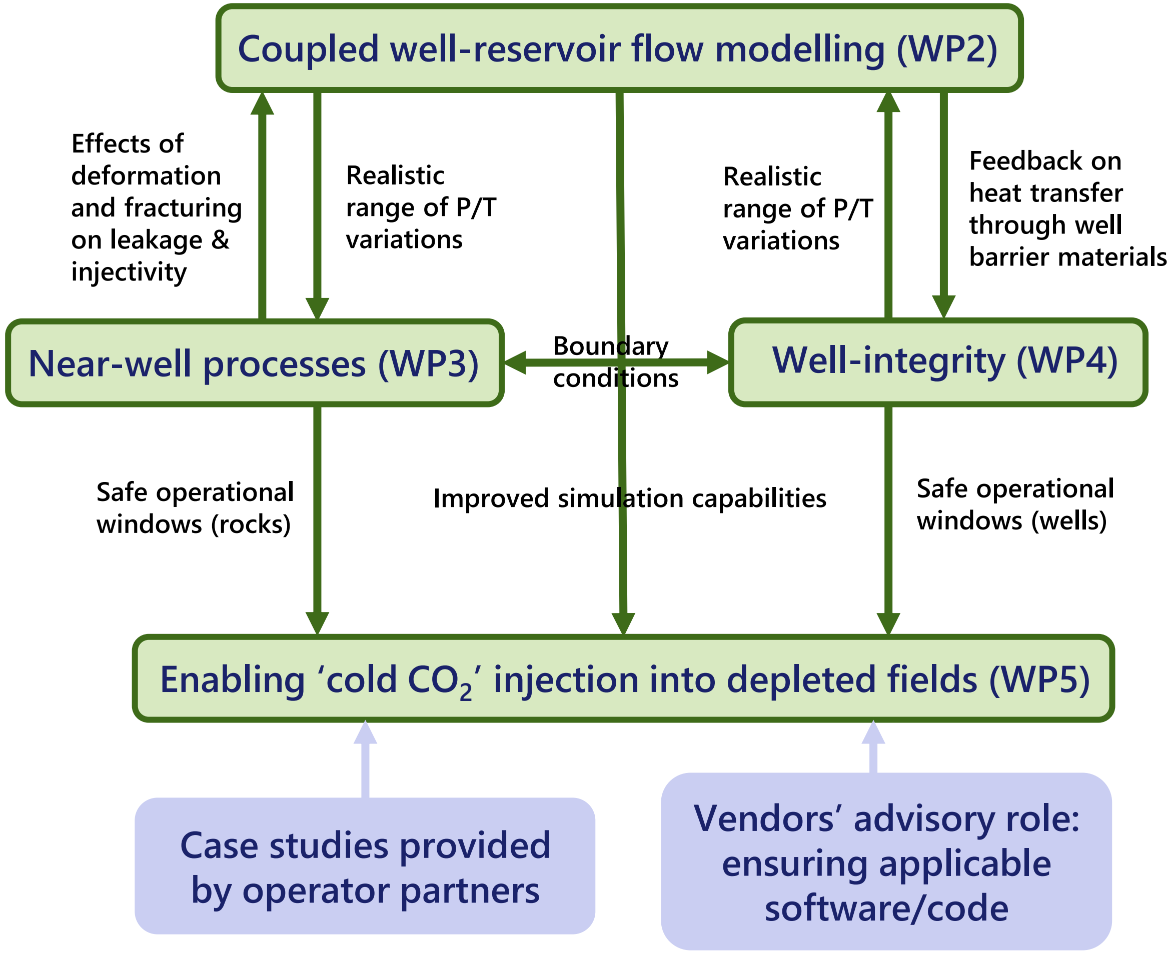
RETURN

Project Overview

Primary objective

Enable safe and cost-efficient long-term CO_2 storage in depleted O&G reservoirs by understanding and handling cooling and CO_2 phase change effects during injection.

- Advantages of depleted reservoirs:
  - Large capacity due to low pore pressure
  - Large pressure margins for safe storage
  - Well-characterized reservoirs
- Challenges/ Drawbacks:
  - Joule-Thomson effect – cooling due to CO_2 expansion may lead to fracturing
  - Legacy wells; non-uniform depletion



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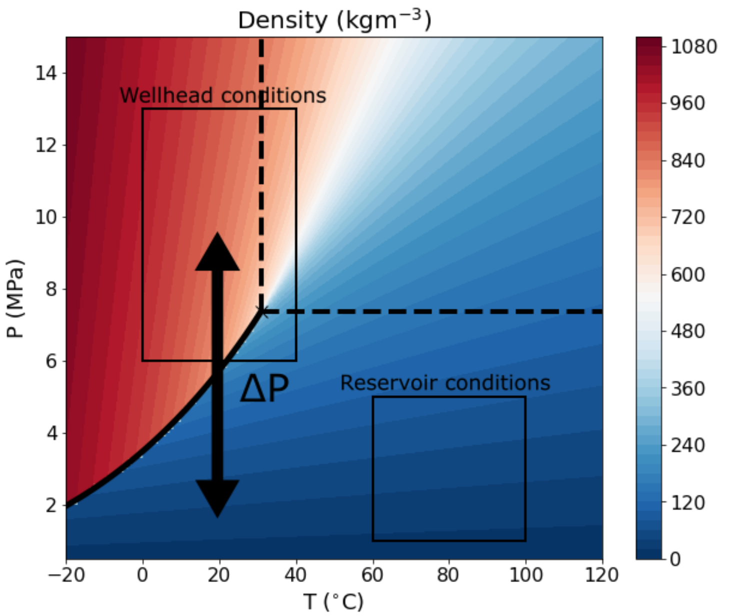
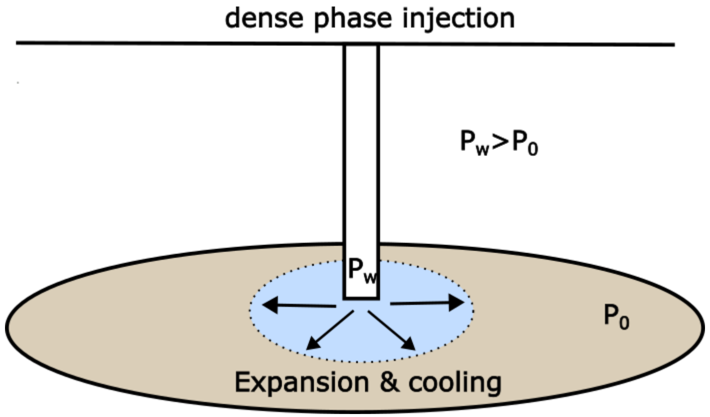
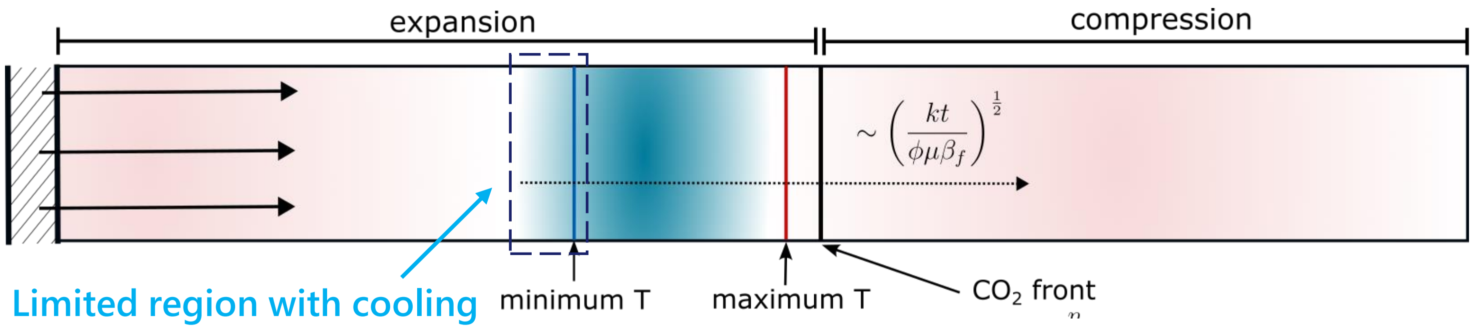
WP2 Coupled wellbore-reservoir flow modelling



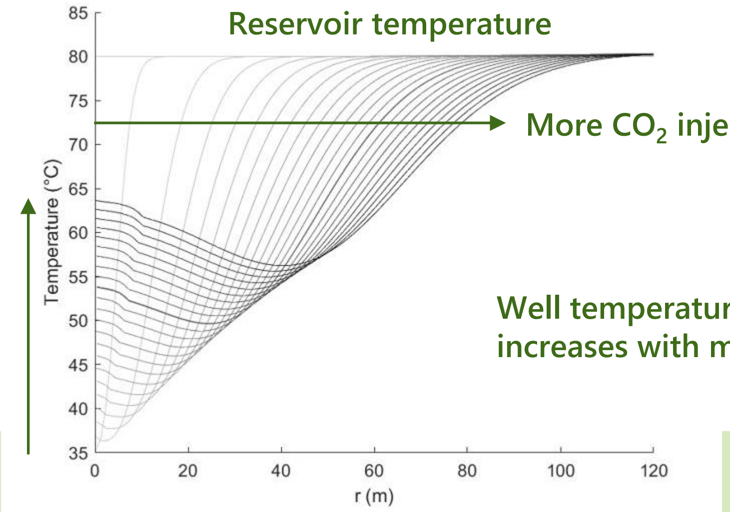


Risks associated with Joule-Thomson cooling during dense phase CO_2 injection:

- Formation of hydrates
- Freezing of pore water
- High thermal stresses
- Jeopardize injectivity & well integrity

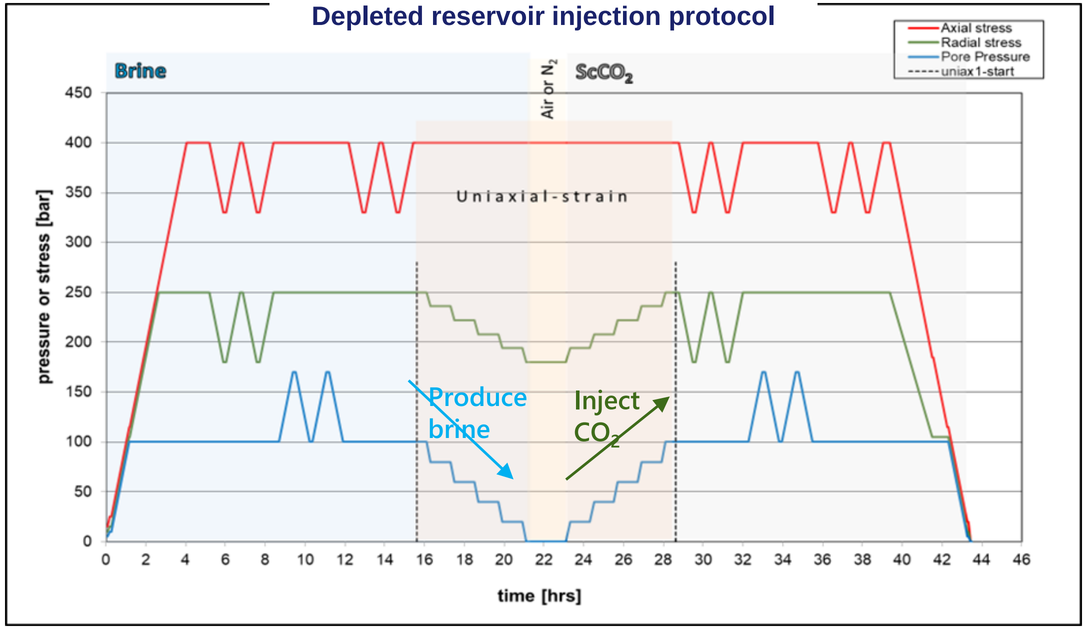


- Task 2.1: Reduced physics models of CO_2 injection with well-reservoir coupling (University of Cambridge)
- Task 2.2: Field Experimental Validation (CMC) – Field labs/ CO_2 injection sites in Canada and Norway → **SPE-212813-MS**
- Task 2.3: Experimental validation using commercial software (TNO)
  - Develop coupled modelling of well-reservoir processes for a variety of boundary conditions

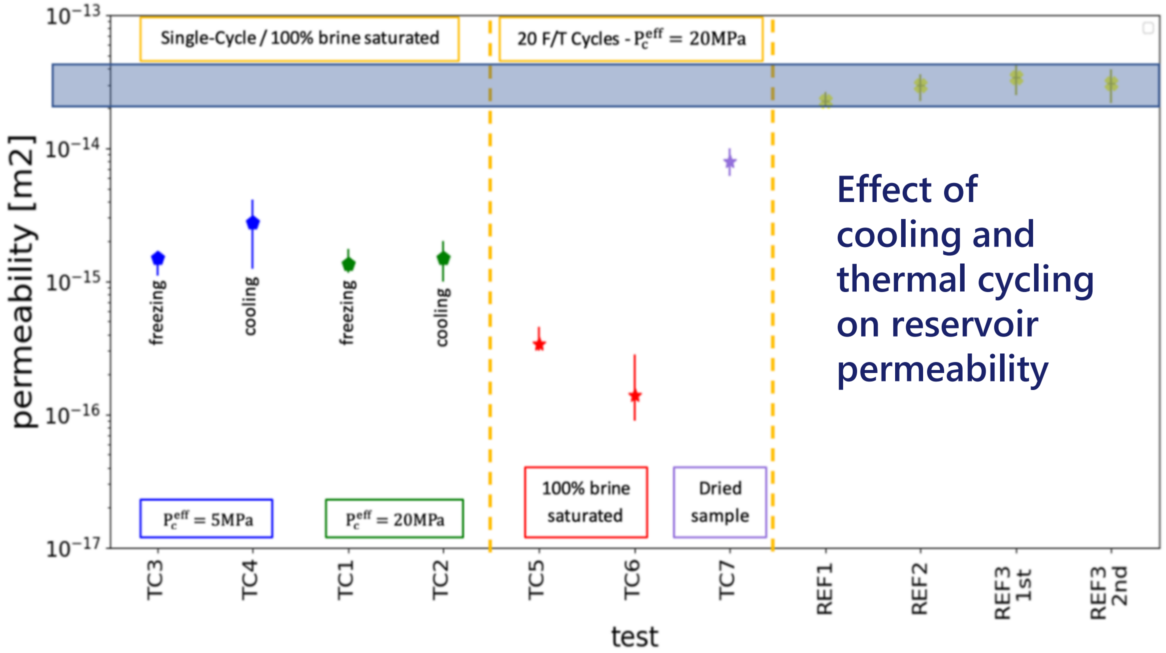


WP3 Near wellbore processes

- Task 3.1 Effect of re-pressurization (UU, Shell, SINTEF)
- Task 3.2 Effect of P/T cycling (UU, Shell, SINTEF)
- Task 3.3 Effect of hydrate formation and salt precipitation (TUBAF, Wintershall Dea, ENI, SINTEF)



CO_2 pore pressure cycling tests: simulate reservoir depletion than CO_2 injection



Effect of cooling and thermal cycling on reservoir permeability

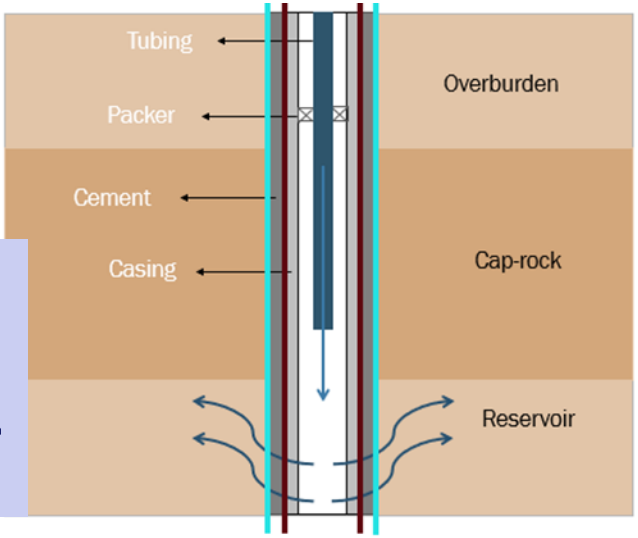
Publications

- ARMA23-609: "Effects of rapid cooling and CO_2 depressurization on the compressive strength of limestone", Verberne et al. (Shell)
- Gas Science and Engineering-118-2023-205101: ''Experimental investigation on the stability of gas hydrates under near-wellbore conditions during CO_2 injection for geologic carbon storage'', Tamaskovics et al. (TUBAF)

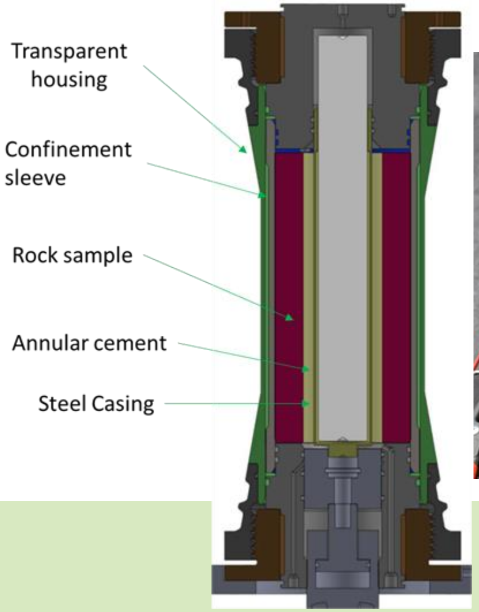
WP4 Well integrity

- Task 4.1: Thermal and pressure cycling experiments
  - Small & Large scale at TUBAF
  - Medium scale at SINTEF
- Task 4.2: Simulation of microannuli formation and resulting leakage
  - Numerical modelling at TNO
  - Develop and incorporate a CO_2 leakage calculator with TNO's well integrity tool
- Task 4.3 Methods for detecting well and near well damage

Due to the pressure, temperature change and cement shrinkage, microannuli may appear at cement-casing or cement-formation interface and cause well integrity failure



Casing/Cement Bond Small scale



WP5 Enabling cold CO_2 injection

- Task 5.1: Define and develop use cases (NZTC)
- Task 5.2: Integration of case studies and injection scenarios
  - Wintershall Dea, TNO, NZTC
  - Integrate the different case studies and outcomes from WP2-4 into generic applicable tools and procedures: 1) Establish a workplan, 2) Reduce uncertainties, 3) Define safe operational windows

Ongoing work!

- Task 5.3: Recommendations for optimized cold CO_2 injection and permit application (TNO)
  - Incorporate and summarize all findings from the technical work in WP2-4 and results from Task 5.2 into generic and specific recommendations for safe CO2 injection into depleted gas reservoirs
  - Including: 1) Workflows, 2) Monitoring options and 3) Implications for permit applications

	Use Case 2 - Ultra depleted Rotligend Reservoir	Use Case 3 - Typical Slochteren sandstone reservoir (Deeper reservoir Dutch North Sea)
Reservoir	Sandstone	Sandstone
Cap rock	Evaporite or shale	basal zechstein 40-50 m thick
Permeability range	75-220mD	10-100mD
Porosity	15-25%	10-20%
Abandonment pressure	20-40bar	40-60 bar
Reservoir temp	100 deg C	115 deg C
Reservoir depth	2000m	3500-4000m
Maximum CO2 Impurities	5%	< 5%
Pressure differential between transported CO2 and reservoir	c. 900psi (60 bar)	40-60 bar initial
Well temp	5 deg to -15 deg C (WH-->BH)	5 (WHT) - 40 (BHT) degC
Target injection rate per well	15-60 kg/s (eqv. 0.5-2 Mta)	15-60 kg/s (eqv. 0.5-2 Mta)
Well type	new injectors	re-purposed or new injectors

Flow assurance → **Well integrity** → **Near wellbore area**

Flow assurance:
- Injection strategy
- Well design

Well integrity:
- Operating envelope
- Cement/ Casing performance

Near wellbore area:
- Operating envelope
- Injectivity
- Brine salinity
- Fault reactivation
- Fracturing

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Net Zero Technology Centre

Technology Driving Transition

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Harbour Energy

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Thank you for your attention!

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