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RETURN: Re-use of depleted oil and gas fields for CO_2 sequestration

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Accelerating CCS Technologies

Speaker

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Agenda

- Return project objectives
- RETURN partners
- RETURN project work packages (1-6)
- TU BAF tasks in WP 3
- TU BAF tasks in WP 4
- Well Integrity for Geological CO2 Storage
- Wellbore integrity experiments and results (WP4)
- Hydrate formation experiments and solutions (WP3)
- Conclusions on TUBAF work packages

RETURN project objectives

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.

Secondary Objectives

- Enable coupled well-reservoir flow modelling including effects of strong cooling and phase changes of the CO_2 during injection. Validate the coupled flow model both experimentally and through field tests and apply the validated model to real field cases.
- Understand how low temperatures, strong temperature variations and strong pressure variations expected during CO_2 injection into depleted reservoirs will affect the near-well region (reservoir and caprock), as well as their impact on storage capacity (depletion/re-pressurization effects) and injectivity.
- Explore the details of how, when, where and why well integrity can be at risk during CO_2 injection into depleted reservoirs resulting from cold temperatures, and strongly varying downhole pressures and temperatures.

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RETURN project objectives

Impact

The project will enable ‘cold CO_2‘ injection into depleted reservoirs, by offering operators recommendations on controllable parameters such as operational patterns and well designs. This will reduce costs and increase safety. The project will also have a strong communication focus.

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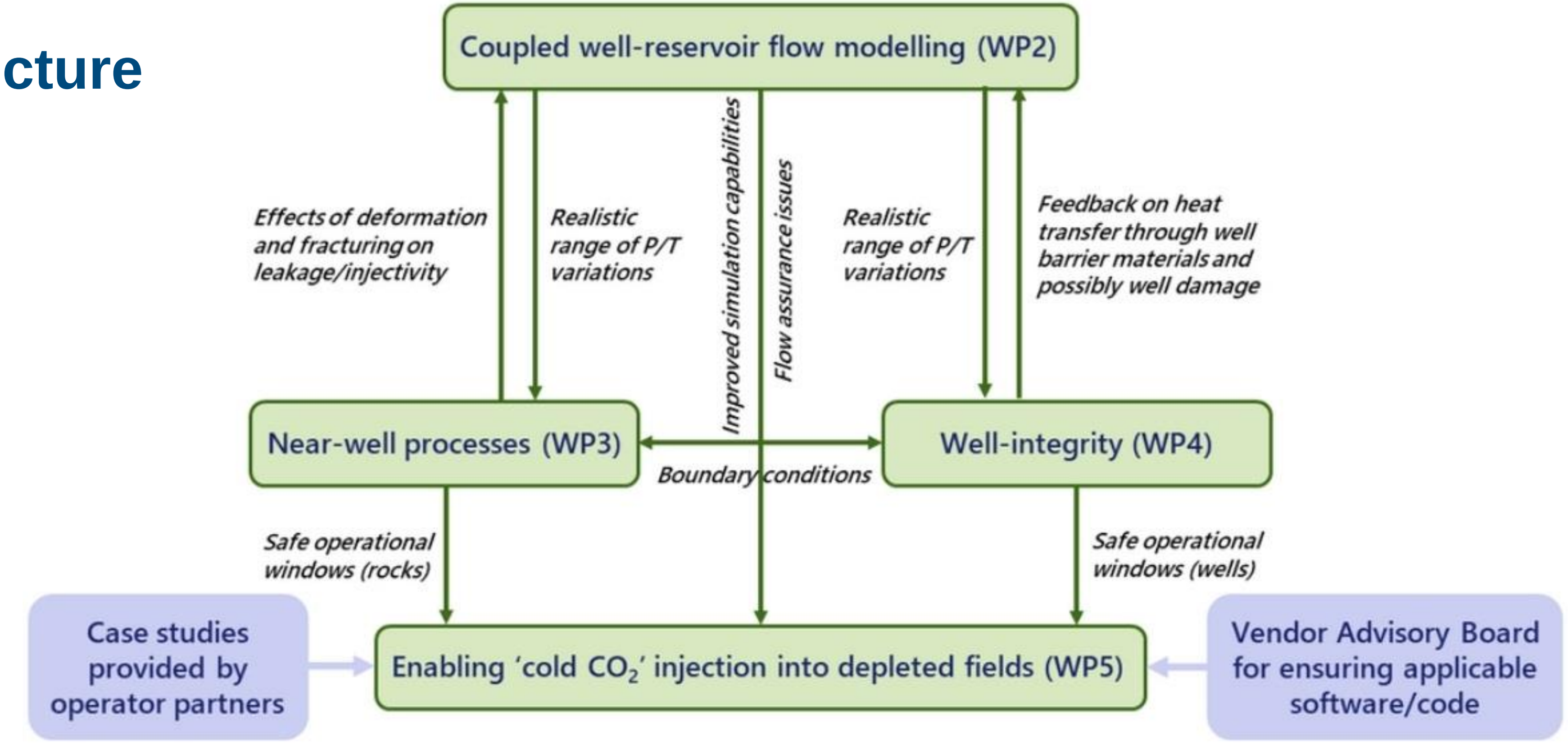
RETURN partners

- The RETURN project is funded through the ACT programme (ACT3) – Grant Number 327322;
- 18 partners form academia, research institutions, and private sector;
- Period from January 2022 to December 2024.
- Project official website : www.return-act.eu

RETURN project workpackages

Project structure



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TU BAF tasks in WP 3

WP3 is divided into four tasks, addressing:

1. The effects of re-pressurization,
2. Pressure/temperature cycling,
3. Injectivity changes upon **hydrate formation and the influence of CO_2-impurities and brine salinity, as well as the porous rock system, on hydrate formation conditions**, and
4. Numerical simulations to upscale the modelled behaviour to field scale.

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TU BAF tasks in WP 4

WP4 will be organized in three tasks, which address the formation of microannuli during CO_2 injection both experimentally and numerically, as well as methods for verifying/diagnosing integrity failures:

1. **Thermal- and pressure-cycling experiments,**
2. Simulation of microannuli formation and resulting leakages,
3. Methods for detecting well- and near-well damage.

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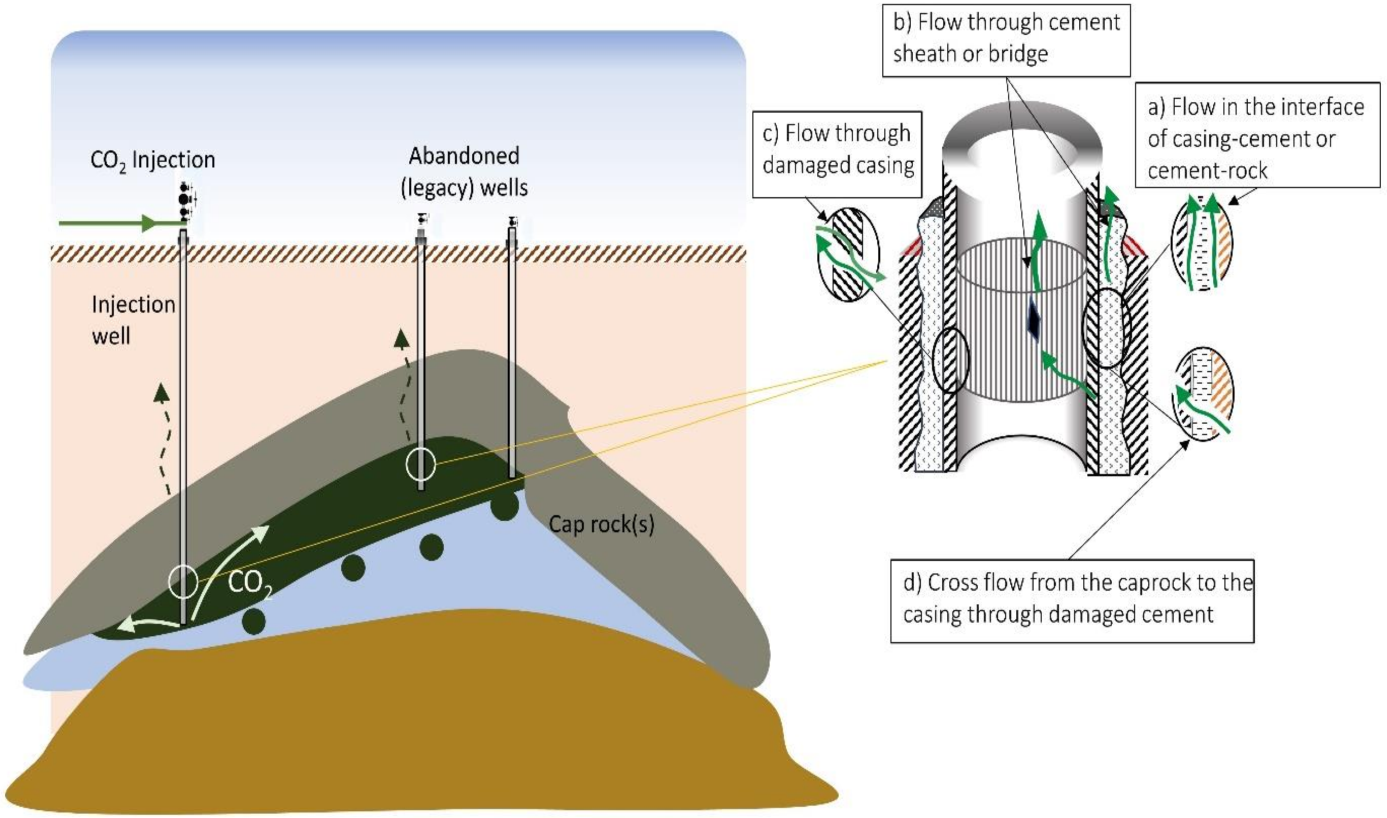
Well Integrity for Geological CO_2 Storage

- Injection of CO_2 causes reduction of the bottomhole temperature of the well
- CO_2 reacts with wellbore components due to its reactivity in the presence of water
- Comprehensive understanding of CO_2 interaction with wellbore components, near wellbore, and caprock is vital to ensure safe GCS operations



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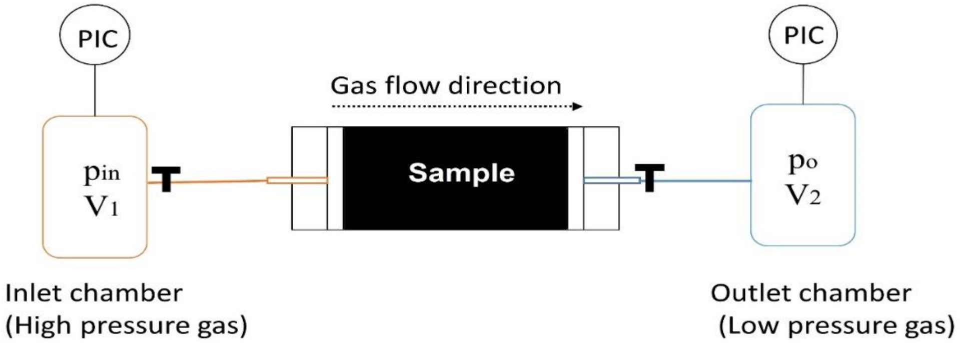
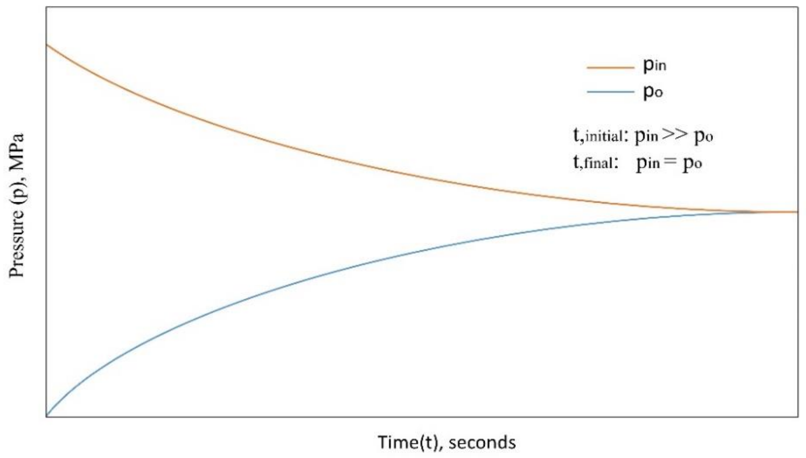
Wellbore integrity experiments and results (WP4)

Objectives, principle, setup

- Effective permeability of cement, rock, cement-rock & casing-cement is measured in the lab
- Rock might be identified as technically tight if the mass flow rate in the magnitude of flow due to diffusion
- Institute in Freiberg developed two laboratory set-ups including evaluation software:
  - Two-chamber method
  - Evaluation Software concerning flow processes of gas or liquids
- Integrity of casing-cement composite at large-scale under cyclic P&T conditions





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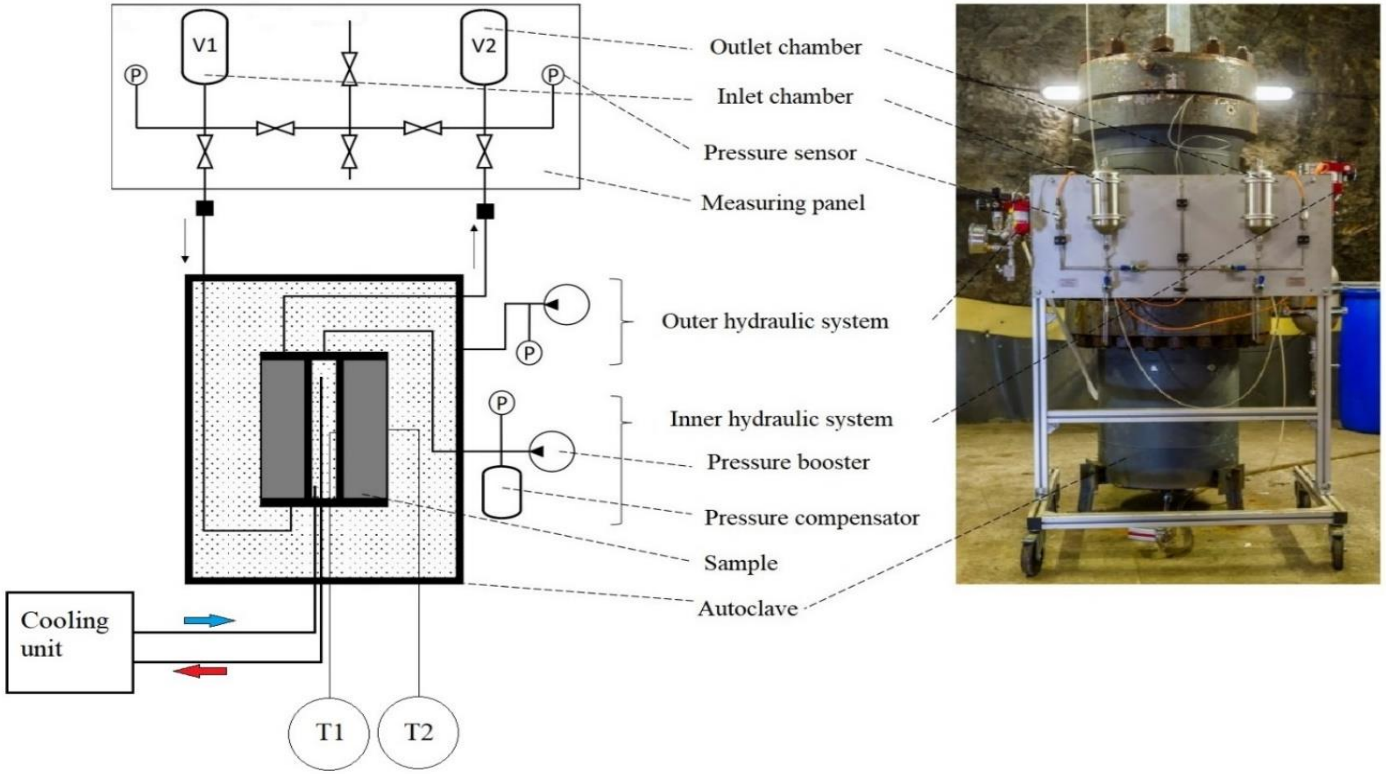
Wellbore integrity experiments and results (WP4)
Experimental Setups



Large-scale **Small-scale**

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Wellbore integrity experiments and results (WP4)

Samples

Caprock (shale)
5x10 cm

Cement-shale composite
10x10 cm

Casing-cement
17.5x29 cm

Cement class G
10x10 cm

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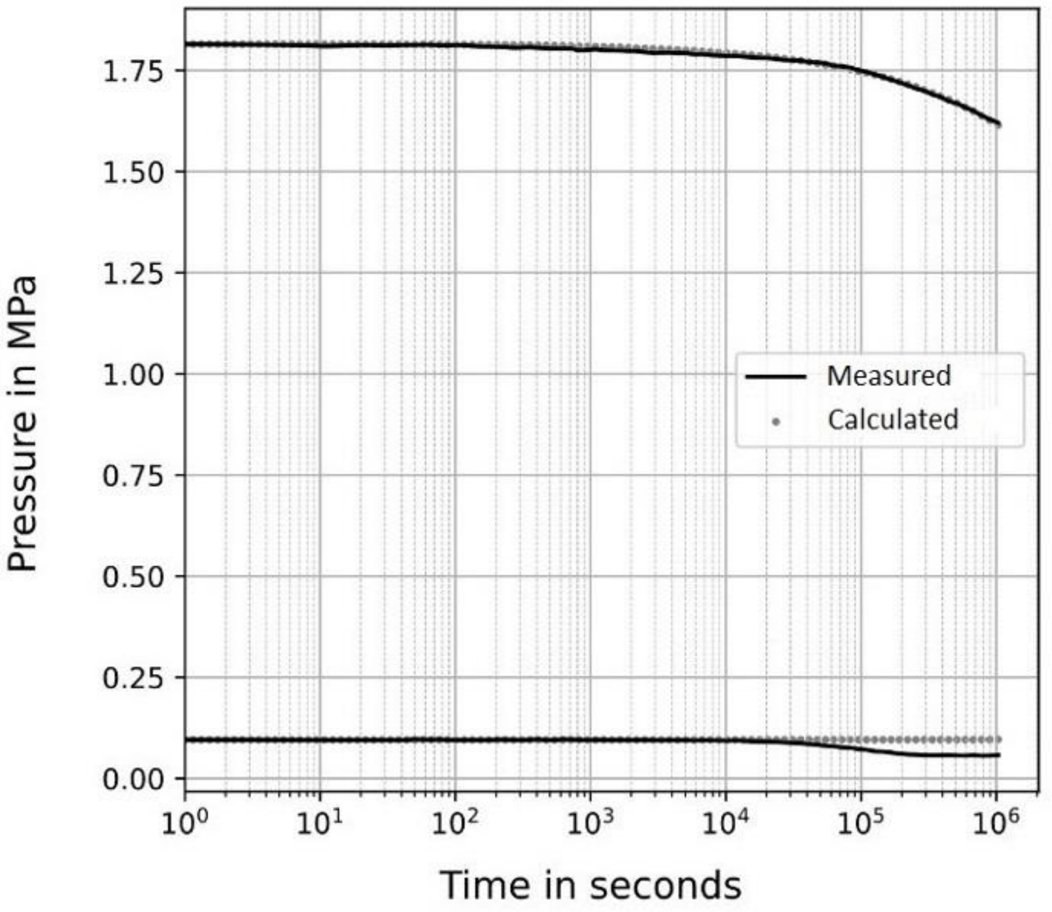
Wellbore integrity experiments and results (WP4)

Results- Permeability of cement

The results of different measurement with CO_2 show either no flow like in the shown figure with complete blockage of the sample due to CO_2 reaction with cement or a low permeability on the order of 10^{-20} m^2 or even less



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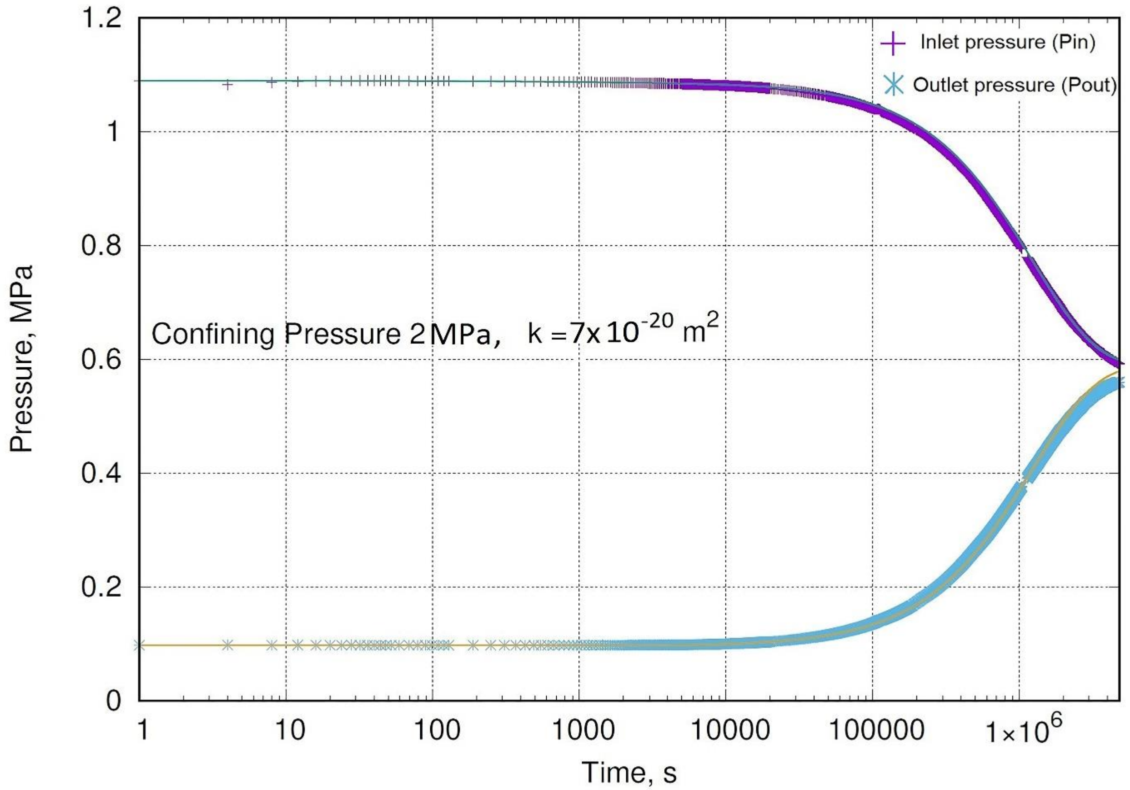
Wellbore integrity experiments and results (WP4)

Results- Permeability of shale & shale-cement

- The permeability of one shale sample has been measured using N_2 to be considered as a reference
- No gas flow has been observed for shale-cement samples the duration of the run (around 11 days)



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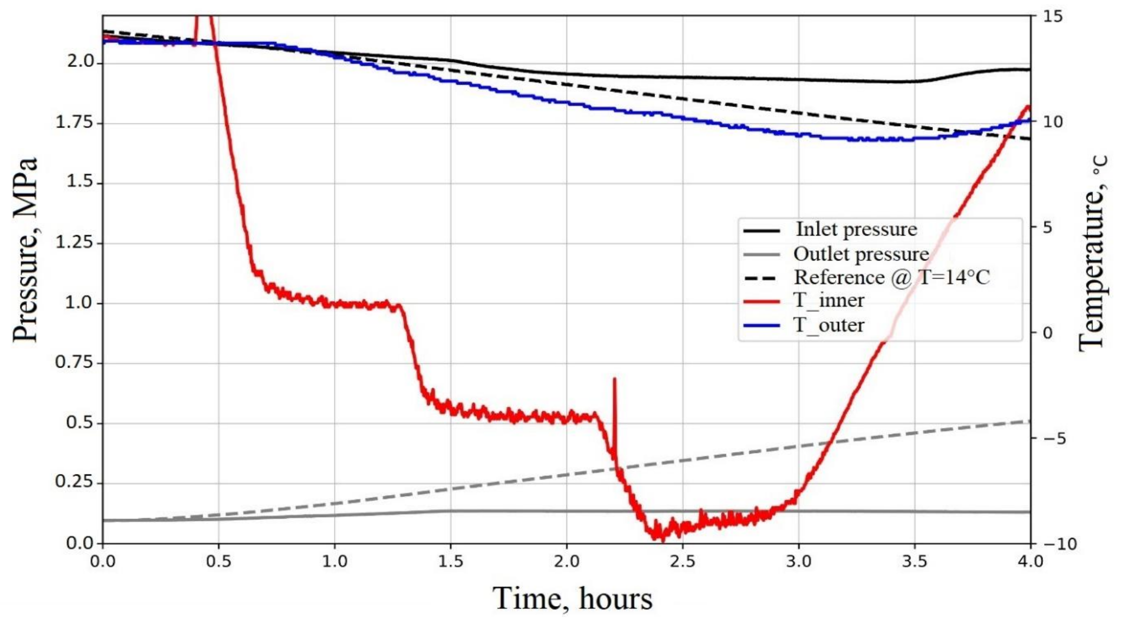
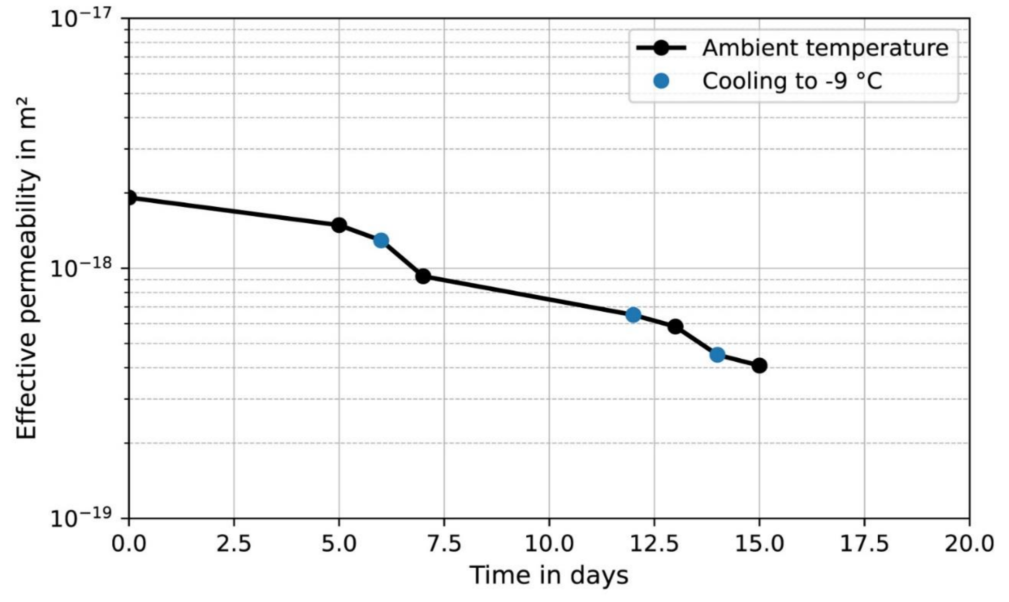
Wellbore integrity experiments and results (WP4)

Results- Permeability of casing-cement/temperature cycling

- No flow at temperature below -4°C in some experiments
- Some experiments flow occur even @-9°C but @ -11°C flow stops completely





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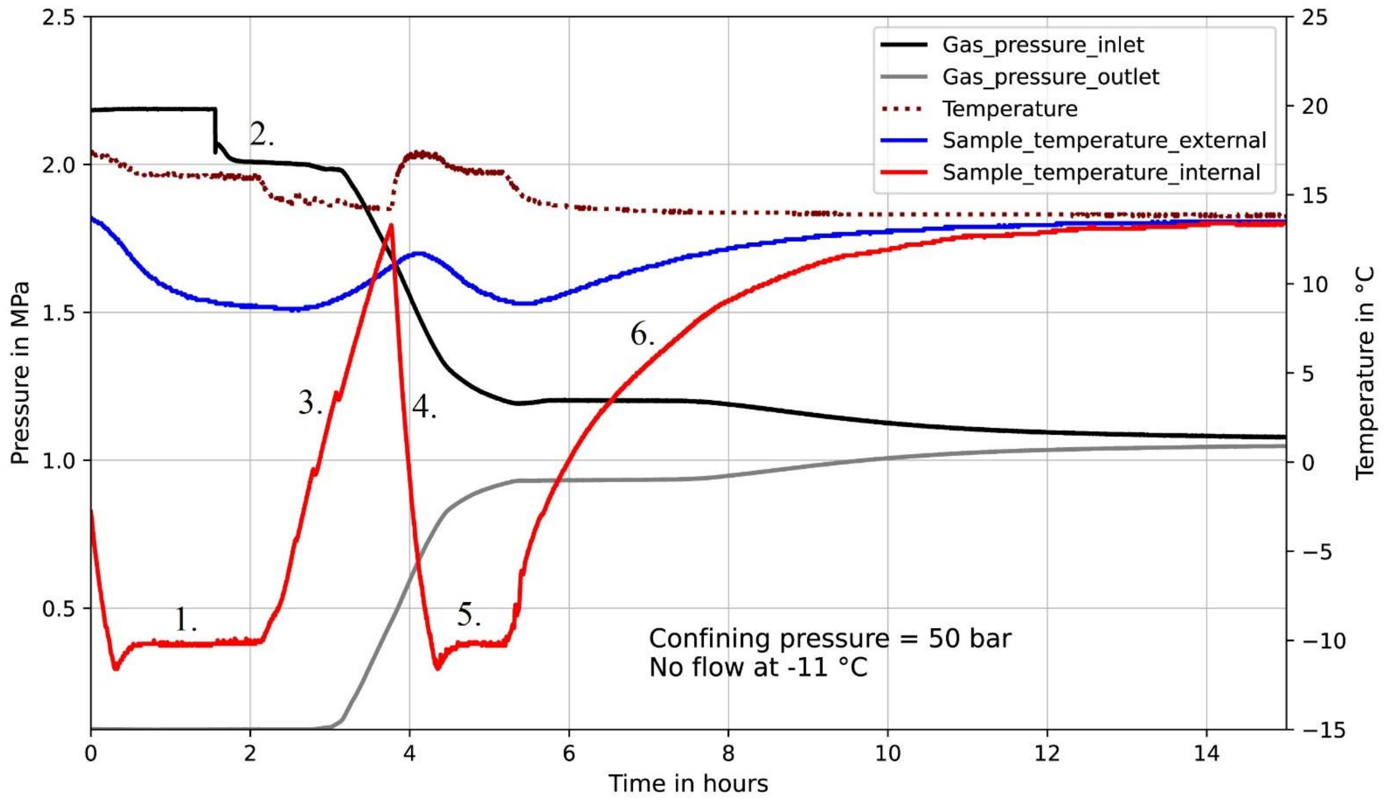
Wellbore integrity experiments and results (WP4)

Results- Permeability of casing-cement/temperature cycling to -11°C

- Cooling for 2 hours to -11°C at the start of the run shows no flow;

- Heating to room temperature and susequent cooling to -11 °C also shows no flow.



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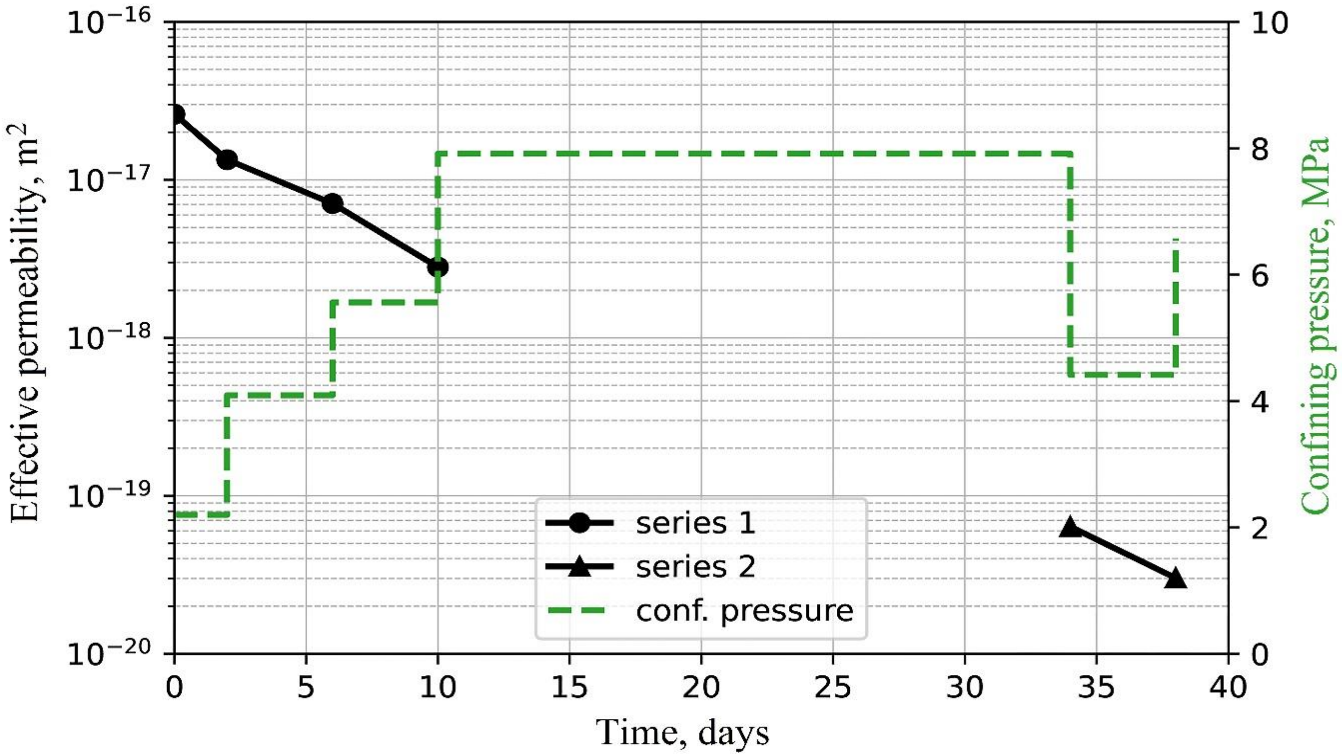
Wellbore integrity experiments and results (WP4)

Results- Permeability of casing-cement/pressure cycling

- The permeability varies due to changes in effective pressure, where a higher effective pressure decreases the permeability and the therefore the ability of the CO_2 to flow



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Hydrate formation experiments and solutions (WP3)

CO2 hydrates

The CO_2 hydrates in storage formations may involve three additional components;

- Salt content of the formation water;
- The presence of the hydrocarbon gases;
- Impurities that is included in the CO_2 stream injected.

The effect of these components on the formation and stabilization of CO2 hydrates is crucial; studies are performed to clarify their effect on the stabilization and/or dissociation.

The study also inludes investigating hydrates formation in:

- Porous media
- Autocalve

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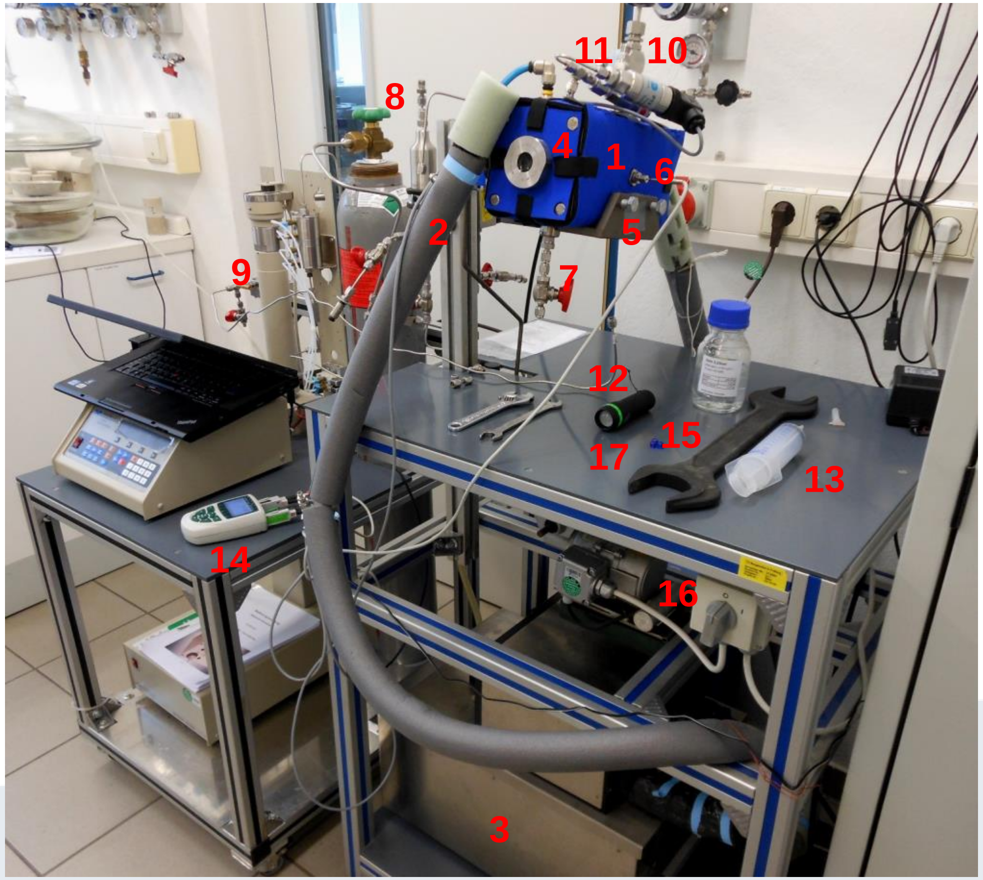
Hydrate formation experiments and solutions (WP3)

Experimental set-up



1) Isolated autoclave (ca. 220 ml)
2) Thermostat hose
3) Thermostat
4) Screw plug with pressure resistant window
5) Shaker
6) Temperature sensor
7) Valve (gas inlet)
8) CO_2 bottle
9) Pump
10) Valve (gas outlet)
11) Pressure relief valve with pressure sensor
12) CO_2 pipe
13) Syringe for water phase
14) Data recording system
15) 3 glas perls for mixing
16) Shaker motor
17) Torch light

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Hydrate formation experiments and solutions (WP3)

Scope of the experiments

A- Investigation of the pure CO_2 gas hydrate with different water salinities;

B- Investigation of a mixed gas phase (CO_2 90 vol% and CH_4 vol 10 %) with varying phases of water acc. to a predefined schedule;

C- Investigation of the inhibition effect of O_2 in synthetic air compared to pure N_2, (CO_2 87 vol% and synthetic air or N_2 13 vol%);

D- Investigation of hydrate building with a typical gas mixture in depleted gas reservoir.

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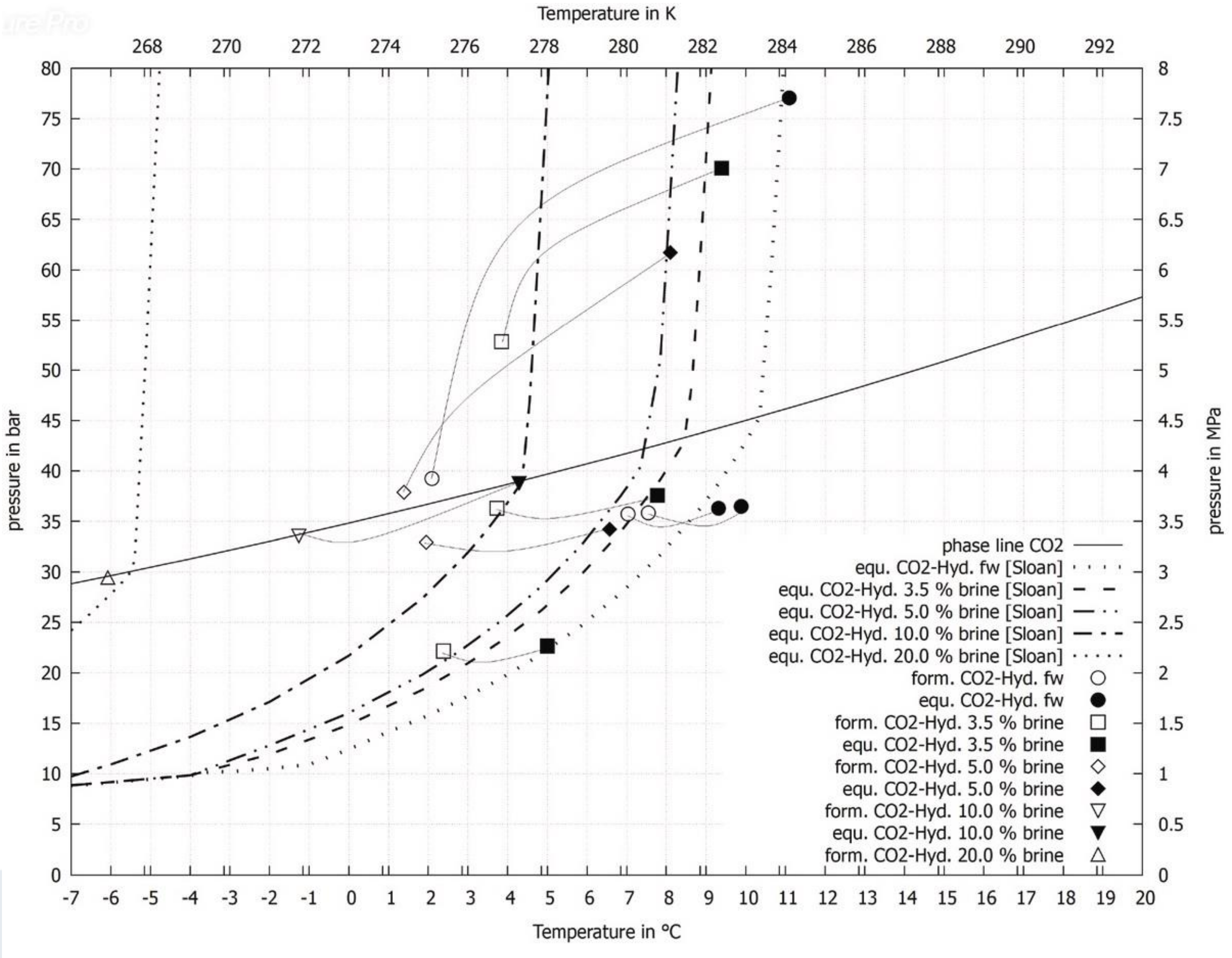
Hydrate formation experiments and solutions (WP3)



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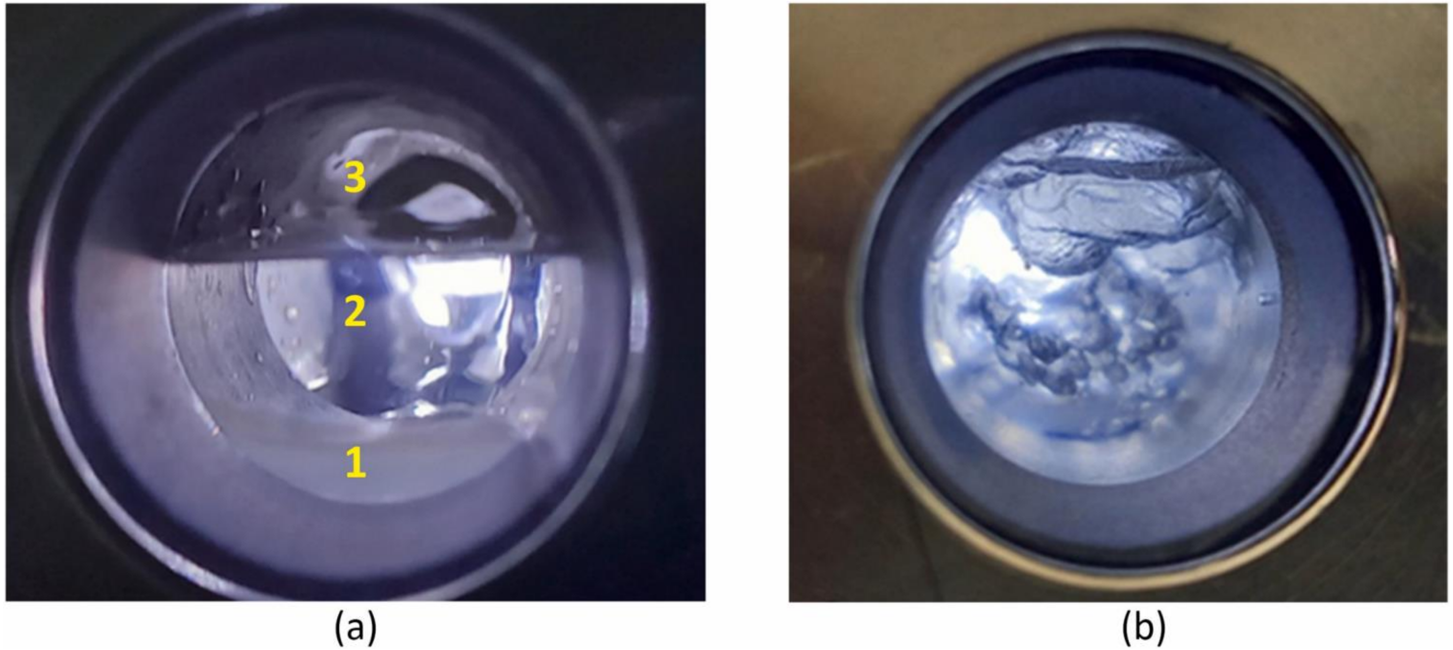
Hydrate formation experiments and solutions (WP3)



(a)Three phases in the gas hydrate cell during filling process. T = 286.45 K, p = 4.76 MPa. Opaque water phase (1), clear CO_2 liq. phase (2), CO_2 gas phase (3).

(b) Picture of CO_2 hydrate with 5.0 % brine.

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Conclusions on TUBAF workpackages

- We conducted experiments at small- and large-scale on cement, caprock, and composites of cement-caprock and casing cement;
- Cyclic pressure- and temperature experiments at large scale on casing-cement are achieved;
- Subzero temperature under -11 °C showed no integrity problems for the composite casing-cement;
- Cycling pressure improved the tightness of casing-cement composite;
- Hydrate formation conditions were determined for different salinities, gases mixtures with CO2;
- Several hydrate inhabitors were also tested and recommended.

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Thank you for your attention

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