# Re-Saturation and Gas Release of Bentonites

Artur Meleshyn, Klaus-Peter Kröhn, Klaus Wieczorek

GRS

Workshop “Mechanical Properties of Bentonite Barriers”

Kaunas, 19-20 June 2017

## Background and scope

- In German repository concepts, bentonite-based seals play an important role which has been broadened by the decision to treat rock salt, clay, and crystalline rock equally as potential host rocks.

- GRS has been working in the field of repository safety research for decades. Research related to bentonites includes experiments in underground laboratories (Grimsel, Mont Terri, Äspö) and in the GRS lab at Braunschweig.

- Presented here are experiments on
  - **Evolution of water distribution** during bentonite re-saturation
  - Thermally induced **gas release**
  - Bentonite **alteration at elevated temperature**

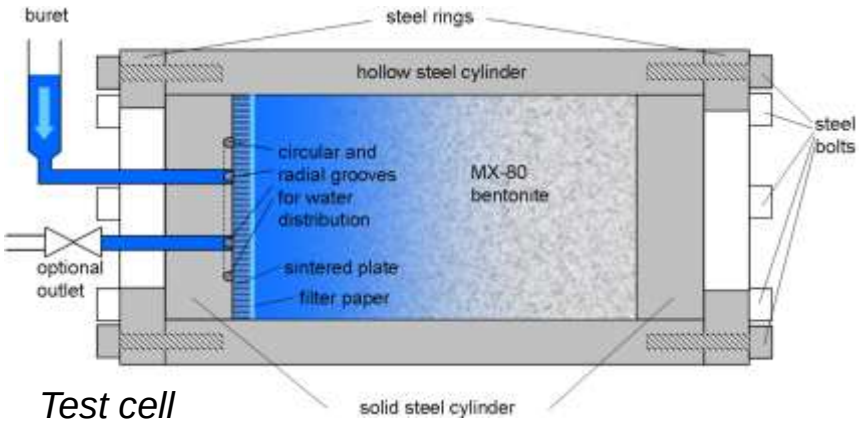
# Evolution of water distribution during bentonite re-saturation (1)

## Objectives

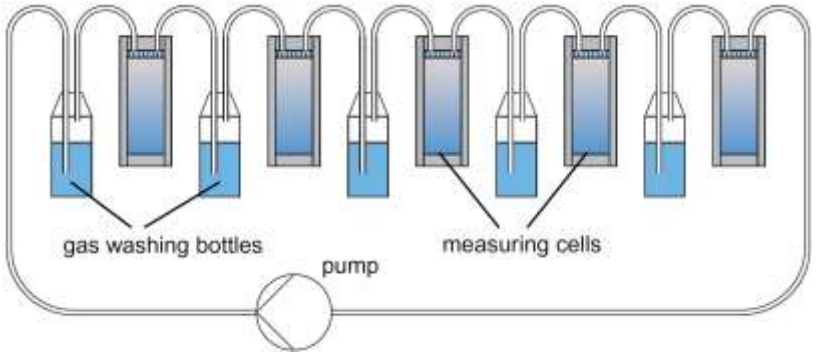
- Determine **dynamics of water content distribution**: Detailed data on the transient water content distribution in the bentonite are a basis for process understanding and modelling
- In particular: Assess relevance of **re-saturation via water vapour**

## Method

- Compacted MX-80 powder (1500 g/m³, initial water content ~10%)
- Placed in test cells for re-saturation with liquid water (Äspö solution) or vapour-saturated air
- Post-test determination of density and water content distribution for pre-defined experiment times



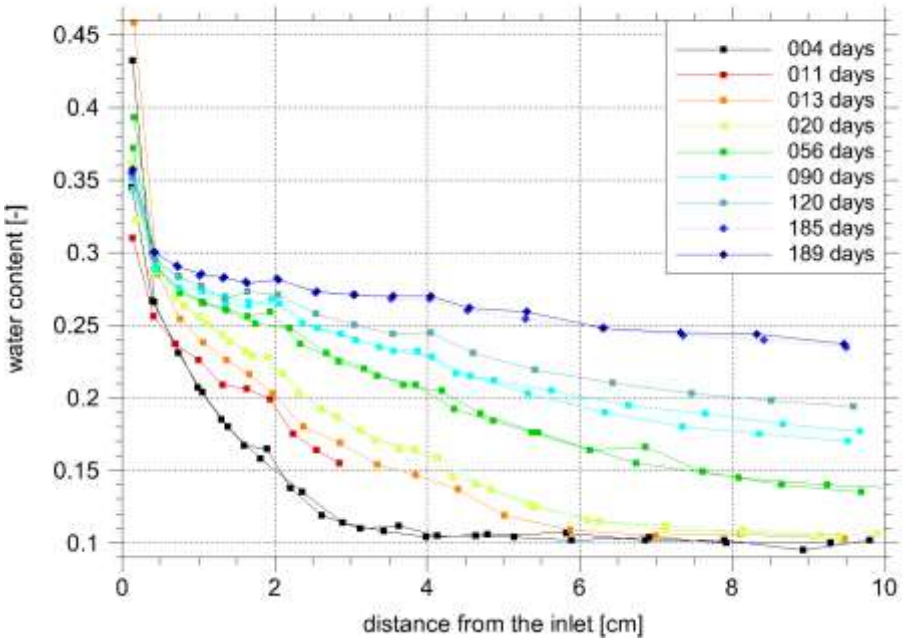

*Test cell*



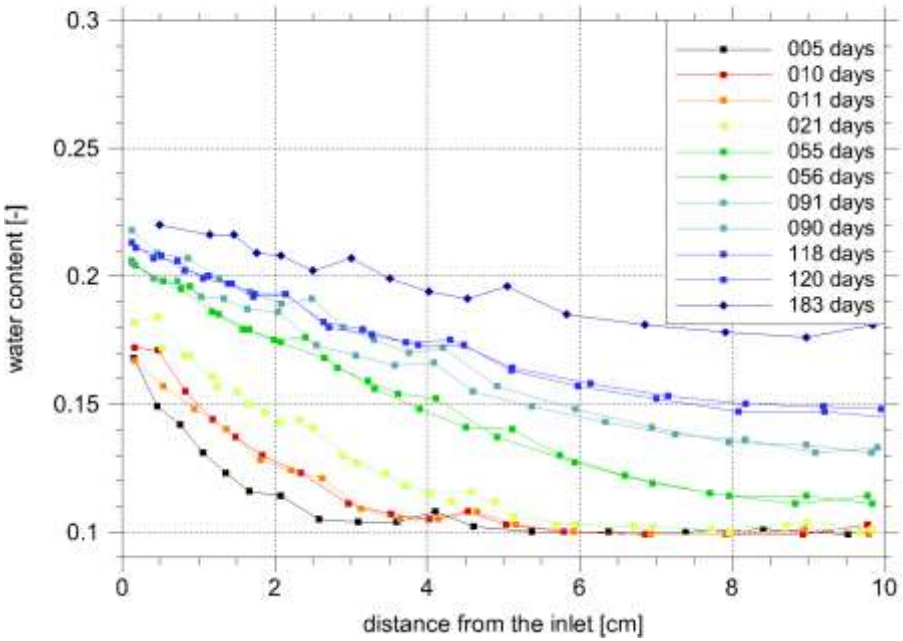

*Cascade of test cells for uptake from water saturated air*

# Evolution of water distribution during bentonite re-saturation (2)

## Measured data




*Re-saturation dynamics for uptake of Äspö-solution*

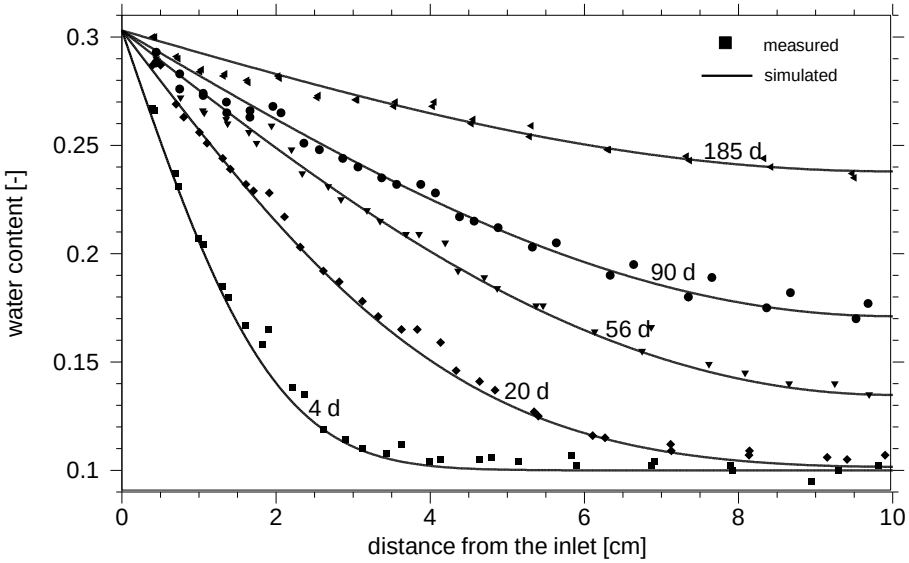



*Re-saturation dynamics for uptake from water-saturated air*

# Evolution of water distribution during bentonite re-saturation (3)

## Results

- **Vapour diffusion** is a powerful re-saturation mechanism
- It appears to be the **dominant water transport mechanism** in re-saturating bentonite
- The experiments were successfully simulated by the VIPER code (based exclusively on vapour diffusion and hydration)




## Prospects

- Ongoing experiments involve a **limited maximum water inflow rate** – this is a relevant boundary condition for a repository in claystone and in crystalline rock

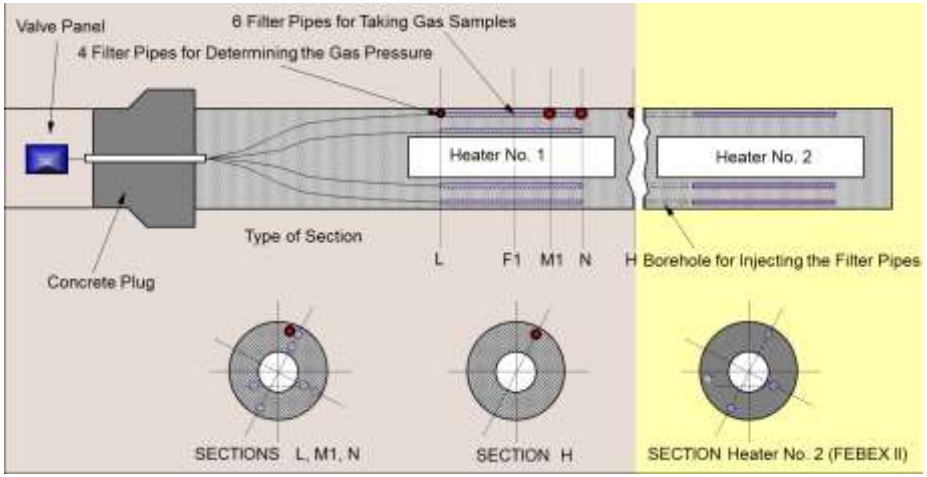
# Thermally induced gas release (1)

## Objective

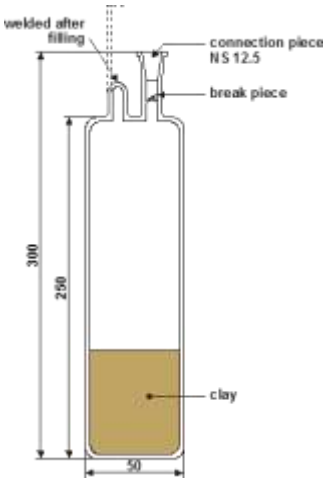
- Determine thermally induced **gas release** from the **FEBEX buffer**

## Method

- In situ (Grimsel Test Site): measurement of the pressure build-up in porous pipes in the buffer; analysis of periodically taken gas samples

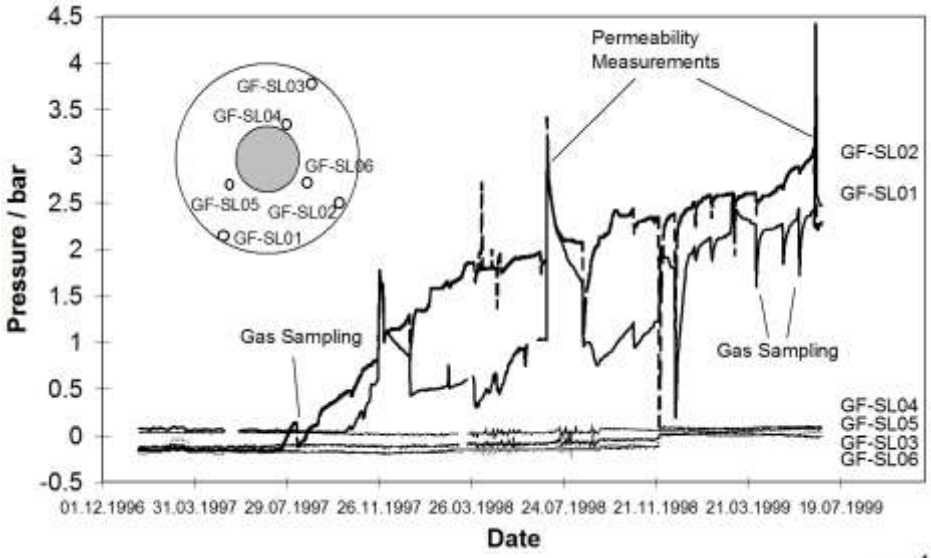



- Laboratory: Dry and wetted (1:1) samples in gas-tight glass vessels were exposed to different temperatures (20 °C, 50 °C, 95 °C) for up to ten years

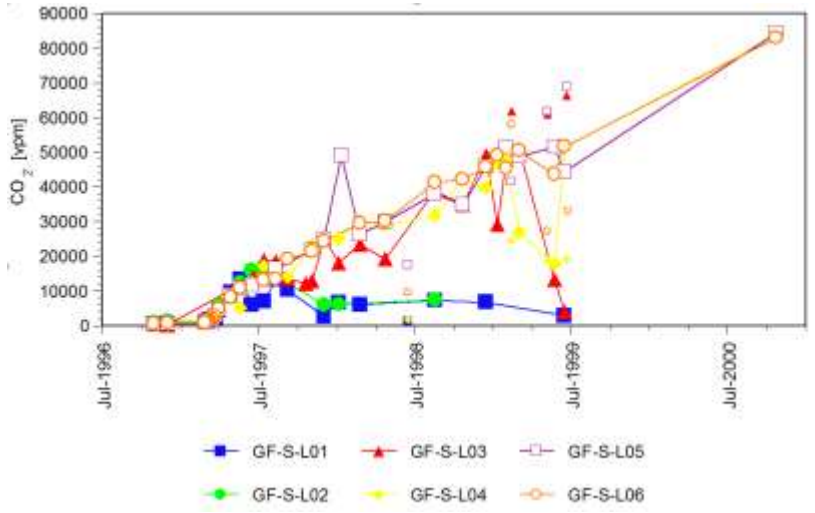


# Thermally induced gas release (2)

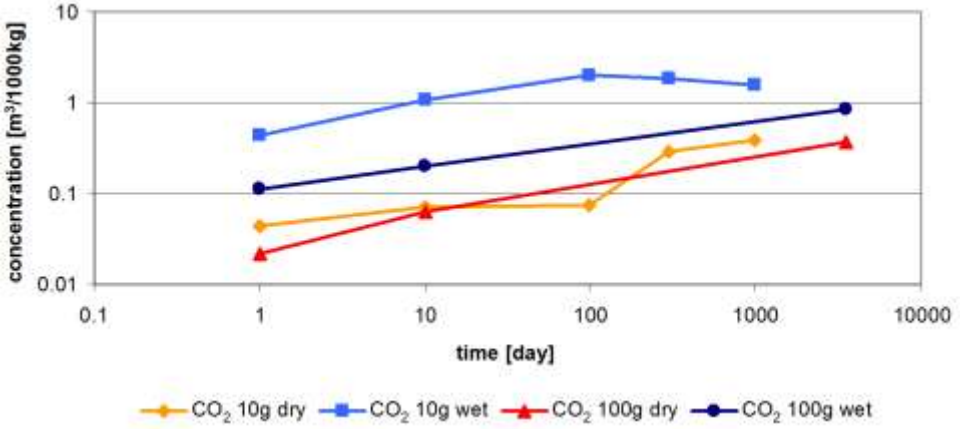
## Measured data




*In-situ pressure evolution*




*In-situ $CO_2$ concentrations*




*$CO_2$ release at 95 °C measured in the lab*

# Thermally induced gas release (3)

## Results

- **Pressure increase** occurred only **close to the tunnel surface** where the pipes were filled with water and sealed in by the re-saturating bentonite (liquid pressure)
- Significant **gas release** (especially $CO_2$) occurred in the “dry” pipes **close to the heater**, where gas could escape via the gaps between blocks and the perforated heater lining
- In the laboratory, significant gas release was measured at **elevated temperature** for both dry and wet samples

# Bentonite alteration at elevated temperature (1)

## Objectives

- Investigate **gas release capacity** of different bentonites
- Determine **source of gas release** (carbonate degradation, organic components?)

## Method

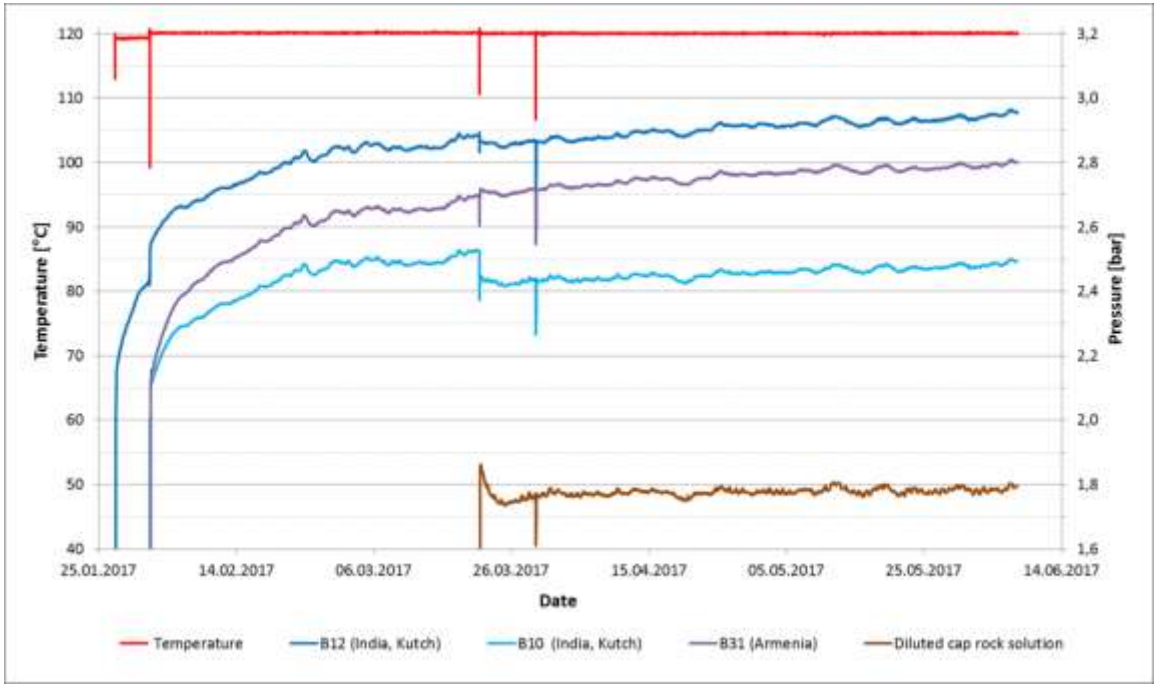
- Bentonite powder mixed with brine (150 g/l) or Opalinus clay pore-water in gas-tight cells (solid/liquid ratio 1/2)

- Exposure to 120 °C for up to one year, fluid pressure measurement, gas sampling and analysis

- Post-test determination of swelling pressure and permeability, mineralogical and microbiological characterization

# Bentonite alteration at elevated temperature (2)

## Measured data




*Pressure evolution in the test cells*

## Results

- Expected end of 2017

## Summary - relevance for Beacon

- **Vapour diffusion** appears to be the **dominant water transport mechanism** in re-saturating bentonite
- **Gas pressure build-up** will affect the effective stress
- Bentonite **alteration occurs in the short term** and may affect mechanical parameters accordingly

## Acknowledgments


- The work presented was funded by the German Ministry of Economics and Energy under the contracts 02E9390, 02E9430, and 02E11344A
- The FEBEX investigations received additional funding from Enresa (contract No. 703229) and from the European Commission (F14W-CT95-0006)


Thank you!

Supported by:

Federal Ministry of Economics and Energy

on the basis of a decision by the German Bundestag