Supplement of Safety of Nuclear Waste Disposal

From process to system understanding with multi-disciplinary investigation methods: set-up and first results of the CD-A experiment (Mont Terri rock laboratory)

Gesa Ziefle et al.

Correspondence to: Gesa Ziefle (gesa.ziefle@bgr.de)

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From process to system understanding with multi-disciplinary investigation methods: set-up and first results of the CD-A experiment (Mont Terri Rock Laboratory)

BGR: Gesa Ziefle, Tuanny Cajuhi, Stephan Costabel, Antoine Fourrière, Markus Furche, Jürgen Hesser, Tilo Kneuker, Herbert Kunz, Ben Laurich, Jobst Maßmann, Christian Ostertag-Henning, Dorothee Rebscher

Swisstopo: Sebastian Condamin, David Jaeggi, Senecio Schefer

Helmholtz (UFZ): Nico Graebling, Olaf Kolditz, Karsten Rink

GRS: Larissa Friedenberg, Kyra Jantschik, Oliver Czaikowski, Klaus Wieczorek

ENSI: Bastian Graupner

KIT/ISU: Franz König, Rainer Schuhmann

BGE: Wolfram Rühaak, Marc Wengler
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Outline

- Introduction CD-A Experiment
- Process understanding
- System understanding
CD-A Experiment: Set-up

Mont Terri Rock Laboratory
CD-A Experiment

Aim:
Investigation of coupled HM-effects in the Opalinus Clay

Important for:
Stability and integrity of a potential repository

- 2 horizontal excavations
- perpendicular to strike of bedding
- no stabilization
- upper sandy facies
- influence of climatic conditions on HM behavior
- CD: “cyclic deformations”
CD-A Experiment: Set-up

**Open twin:**

„natural“ niche containing coupled HM effects due to desaturation

**Closed twin:**

„air conditioned“ niche avoiding desaturation effects as much as possible
CD-A Experiment: Climatic conditions

Relative humidity

- **Closed niche:** Constantly high relative humidity
- **Open niche:** Seasonally influenced relative humidity
CD-A Experiment: Relevant effects

- Climatization
  - Desaturation
  - Swelling/Shrinkage
  - Saturation dependent material parameters

- Excavation (2019):
  - Stress redistribution
  - Pore pressure changes

Open twin:

Closed twin:

Air lock
Desaturation around the niches – numerical modelling

Numerical modelling (OpenGeoSys6) of the twin niches also indicates the differences of the desaturated zone (already) two years after excavation.
Desaturation around the niches: geophysical measurements

Electric Resistivity Tomography (ERT) measurements at ring profiles: relative changes of the resistivity

Evolution of desaturated zone
Desaturation around the niches: geophysical measurements

Nuclear magnetic resonance measurements (NMR) provide information about the water content.

Legend:
- b = 16 mm
- a = 50 mm
- c = 10 - 25 mm

- Permanent magnets
- Measurement coil
- Sensitive volume

Costabel (BGR)

Resistivity – water content – relation

Multi-disciplinary interpretation aiming on:
- Process understanding
- Constitutive material models
- Validation of numerical approach
Characterization of Opalinus Clay

ERT:
Electric Resistivity tomography

MSM:
Mini-Seismic

NMR:
Nuclear Magnetic Resonance

CCM:
Calciumcarbid-Method

Taupe:
Time domain reflectometry (TDR)

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<th>Lith.</th>
<th>ERT</th>
<th>MSM</th>
<th>NMR/CCM</th>
<th>Taupe</th>
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Table 2: Investigation methods and available information. [ +: information available, -: no information available, *: may provide information about their impact on physical effects, (): limited information]. Lith. = Lithological investigations on drill cores.
Borehole investigations

- Lithologic characterization indicates sub-facies types and fault zones
- Impact of sub-facies types on resistivity
- No clear correlation with water content
- Temporal evolution indicates an impact of some fault zones on water content
- Different climatic conditions seem to affect the properties of the EDZ
Geologic mapping

Figure 32: N-S striking fault in the Closed Twin, here in the ceiling. Displacement (A) and rotation (B) of the fault when crossing bedding parallel faults.

Figure 35: Open Twin, system of small flatly dipping (238/07) veins (red) showing drag folds (orange) and cm displacement of bedding planes (green).

Jaeggi et al. (2020)
Extensometer measurements in relation to detected fault zones

Measurements indicate impact of some fault zones on convergence behavior

Further investigations needed!
Conclusion

CD-A Experiment:

• Increased process understanding of coupled long-term HM effects
• Geologic characterization + geophysical measurements + numerical modelling + visualization
• Multi-disciplinary approach + close collaboration
• Aiming on an increased system understanding
• Calibration/Verification of constitutive modelling approaches

Preliminary results:

• Measurements and numerical modelling illustrate desaturation and convergence around the twin niches
• Impact of heterogeneities such as sub-facies types and fault zones on coupled HM effects

Thanks to the CD-A Team!!!