MOBILITY MISSION REPORT

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MISSION TITLE

EURAD Training on multiphysical couplings in geomechanics

DESCRIPTION

Concerned organisations

- Research entities
- Technical support organisations
- Waste management organisations

Concerned infrastructures or facilities

N.A.

Concerned phases

Post-closure

Themes and topics

- Theme 3: Engineered barrier system (EBS) properties, function and long-term performance

    - Clay-based backfills, plugs and seals
    - EBS system understanding
- Theme 4: Geoscience to understand rock properties, radionuclide transport and long-term geological evolution
    - Perturbations (gas, temperature and chemistry)
- Theme 7: Performance assessment, safety case development, and safety analyses
    - Performance assessment and system models

Keywords

Clay-rich materials; gas migration; geomechanics; experimental testing; numerical modelling

EXECUTIVE SUMMARY

Geomechanics plays a significant role in the understanding of the multiphysics and multiscale processes taking place in a geological disposal facility for radioactive waste. The objective of the school was to introduce state-of-the-art understanding, concepts and methods related to thermo-hydro-mechanical coupled processes, the physical impacts of thermal loading and the mechanistic understanding of gas migration in geomaterials. Results arising from the EURAD project were also integrated to the school, and a half day was dedicated to presentations by early-career researchers. A visit to the HADES Underground Research Laboratory was organised on the last day of the school.

1. MISSION BACKGROUND

1.1. R&D background

Geomechanics plays a significant role in the understanding of the multiphysics and multiscale processes taking place in a geological disposal facility for radioactive waste. The objective of the school was to introduce state-of-the-art understanding, concepts and methods related to thermo-hydro-mechanical coupled processes, the physical impacts of thermal loading and the mechanistic understanding of gas migration in geomaterials. Results arising from the EURAD project were also integrated to the school, and a half day was dedicated to presentations by early-career researchers. A visit to the HADES Underground Research Laboratory was organised on the last day of the school.

1.2. Mission objectives

The objective of the mission was to give a lecture in the session on "Advanced multiphysics modelling of geomaterials: multiscale approaches and heterogeneities" and present the conclusions of the research carried out by my group within the EURAD project, thereby enhancing the impact of my research and the EURAD project.

1.3. Mission request

Participation to the second GAS/HITEC Joint training course.

1.4. Mission composition

Host organisation

University of Liege

Host facility

University of Liege, Sart-Tilman campus

Mission dates

28th August to 1st September 2023

2. MAJOR PRACTICES, TECHNIQUES, METHODS, TOOLS OR SYSTEMS OPERATED OR STUDIED

Klikněte nebo klepněte sem a zadejte text.

2.1. Practice, technique, method, tool or system operated or studied during the mission

Numerical modelling of gas migration processes in clay barriers

Description

The efficient, sustainable and safe implementation of many engineering activities in the subsurface, including the geological disposal of radioactive waste, requires a detailed understanding and reliable prediction capacities of gas migration in geomaterials. This is a complex, strongly coupled problem, which is affected by the material properties, material state, gas characteristics, gas production/injection rate, and scale of observation, among others, and requires advanced numerical tools.

Usage

I delivered a lecture on “Advanced multiphysics modelling of geomaterials: multiscale approaches and heterogeneities”.

Benefits

The lecture slides are included in deliverables of the EURAD project.

Limitations

N.A.

Applicability

N.A.

2.2. Practice, technique, method, tool or system operated or studied during the mission

N.A.

Description

N.A.

Usage

N.A.

Benefits

N.A.

Limitations

N.A.

Applicability

N.A.

2.3. Practice, technique, method, tool or system operated or studied during the mission

N.A.

Description

N.A.

Usage

N.A.

Benefits

N.A.

Limitations

N.A.

Applicability

N.A.

2.4. Practice, technique, method, tool or system operated or studied during the mission

N.A.

Description

N.A.

Usage

N.A.

Benefits

N.A.

Limitations

N.A.

Applicability

N.A.

3. MISSION FINDINGS AND CONCLUSIONS

3.1. Lessons learned and conclusions

1. The presented FEM+z approach can simultaneously simulate
- Diffusion/advection of dissolved gas and two-phase flow both in the continuous porous medium
- Gas flow along/across macroscopic cracks induced and propagated by the gas pressure.
2. Self-sealing is achieved automatically when the induced cracks close as the gas pressure is reduced.
3. Experimental observations are qualitatively reproduced by the model.
4. The explicit representation of discontinuities (e.g., fractures, joints, faults, material interfaces, etc.) allows a more detailed study of the effect of these features in the overall pneumo-hydro-mechanical behaviour of the clay barriers.
5. *Dialogue between experimentalists and modellers is crucial to better understand the observed behaviour and the impact of testing equipment and protocols… especially when dealing with gas!*
- *Realistic representation of clay-experimental device interfaces and boundary conditions is important as these may have a significant influence on the results.*
- *In addition to the gas injection, simulation of the initial conditioning of the sample, as well as the dismantling process may be necessary to explain experimental observations.*

3.2. Relevant findings and conclusions for home organisation

See above.

3.3. Relevant findings and conclusions for host organisation

See above.

3.4. Relevant findings and conclusions for other organisations

See above.

4. POTENTIALS FOR IMPROVEMENT OR DEVELOPMENT

4.1. Generic potentials

Routes for improvement of the presented modelling approach include:

1. Further developments to allow a quantitative validation of the model, e.g.:
- implementation of the pathway dilation mechanism (continuum domain)
- introduction of variability/heterogeneity of the material properties
- extension to 3D
2. Numerical modelling of gas injection experiments:
- Realistic PHM representation of clay-device interfaces can significantly influence the results.
- In addition to gas injection, simulation of the initial sample conditioning as well as the disassembly process may be necessary to explain the experimental observations.

a. Potentials for home organisation

See above.

b. Potentials for host organisation

See above.

APPENDICES

Mission journal

Monday 28 August	
9.00 – 12.30	Basics of thermo-hydro-mechanical processes in geomaterials Sebastià Olivella
13.30 – 17.00	Basics of experimental testing of geomaterials Alessio Ferrari
Tuesday 29 August	
9.00 – 12.30	Constitutive modelling of thermo-hydro-mechanical processes in geomaterials Jean-Michel Pereira
13.30 – 17.00	Development, validation and maintenance of numerical codes Olaf Kolditz
Wednesday 30 August	
9.00 – 12.30	PhD day: poster sessions and pitches
13.30 – 17.00	Advanced multiphysics experimental testing and imaging of geomaterials Laura Gonzalez-Blanco, Dragan Grigc, Jiri Svoboda, Andrew Wiseall
Thursday 31 August	
9.00 – 12.30	Advanced multiphysics modelling of geomaterials: multiscale approaches and heterogeneities Pierre Bésuelle, Frédéric Collin, Anne-Catherine Dieudonné, Sebastià Olivella
13.30 – 17.00	*In situ* THM and gas experiments Arnaud Dizier, Emiliano Stopelli, Rémi de la Vaissière, Maria Victoria Villar

MISSION BENEFICIARY

Anne-Catherine DIEUDONNÉ
Assistant Professor of Multiphysics Geomechanics
Faculty of Civil Engineering and Geosciences, Department of Geoscience & Engineering
Delft University of Technology (the Netherlands)

PARTNER EXPERTS CONTRIBUTING TO THE MISSION

Host organisation experts

- Professor Frédéric Collin, Department of Urban and Environmental Engineering, University of Liege

Home organisation experts

- Dr. Anne-Catherine Dieudonné, Department of Geoscience & Engineering, Delft University of Technology

Other organisations experts

- Dr. Séverine Levasseur, ONDRAF/NIRAS

REPORT APPROVAL

Date	Beneficiary	Home mentor/supervisor	Host mentor/supervisor
3/5/24	Anne-Catherine Dieudonné	Michael Hicks	Frédéric Collin