MOBILITY MISSION REPORT

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MISSION TITLE

Participation to the second GAS/HITEC Joint training course, held by EURAD WP GAS & WP HITEC

DESCRIPTION

Concerned organisations

- European Joint Programme on Radioactive Waste Management (EURAD)
- University of Liège (ULiège)
- Delft University of Technology (TU Delft)
- École Polytechnique Fédérale de Lausanne (EPFL)
- Ecole Nationale des Ponts et Chaussées (ENPC)
- Helmholtz Centre for Environmental Research (UFZ)
- Universitat Politècnica de Catalunya (UPC)
- Czech technical university in Prague (CTU)
- British Geological Survey (BGS)
- French national radioactive waste management agency (ANDRA)

Concerned infrastructures or facilities

- University of Liège
- Tabloo

- HADES underground research laboratory

Concerned phases

- Phase 0: Introduction
- Phase 1: Lectures and poster sessions
- Phase 2: Site and laboratory visits

Themes and topics

- Theme 1: Theoretical knowledge of coupling processes in geomaterials
  - Thermo-hydro-mechanical (THM) coupling
  - Constitutive model
- Theme 2: Advanced multiphysics modelling of geomaterials
  - Multiscale approaches and heterogeneities
  - Development, validation and maintenance of numerical codes
- Theme 3: Advanced multiphysics experimental testing in geomaterials
  - Laborotory gas injection test
  - Imaging of geomaterials
- Theme 4: In-situ experiment in geomaterials
  - THM and gas experiments

Keywords

Radioactive waste disposal, clay barrier, coupled processes, gas migration, risk evaluation

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 is to introduce state-of-the-art understanding, concepts and methods related to the mechanistic understanding of gas migration in geomaterials. The main practices of this mission is to attend lectures. The topics include theoretical knowledge of coupling processes, advanced multiphysics modelling, laboratory and in-situ THM and gas experiments in geomaterials. In addition to the lectures, a poster session was held to allow the attendees to discuss their results with each others. A site visit to an underground research laboratory of radioactive waste disposal is also included. After the mission activities, the applicant obtained knowledge and understood more deeply about the coupling processes, muti-scale modelling approaches and the cutting-edges results of THM and gas experiments in geomaterial.

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 second GAS/HITEC Joint training course held by EURAD WP GAS & WP HITEC aims to 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.

1.2. Mission objectives

The applicant is a PhD student working on the numerical modelling of gas migration in clay-rich host formations. The applicant's objectives to attend this training course is to gain knowledge from this training course, since the state-of-the-art understanding of gas migration processes, together with results arising from the EURAD project, will be presented. The applicant also plans to present a poster to share his current knowledge and discuss with the peers. The applicant believes he can get valuable comments and suggestions with regard to his current work and future plan.

1.3. Mission request

Participation to the second GAS/HITEC Joint training course

1.4. Mission composition

Host organisation

University of Liège , Liege, Belgium.

Host facility

ULiege (Sart-Tilman campus)

Mission dates

28 August 2023 – 1 Septemper 2023

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

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

Poster presentation

Description

A poster session is held on the third day of the PhD school, allowing the attendees to show a poster and present their research.

Usage

The applicant made a short presentation to introduce his research background and then showed and discussed the details of his poster (title: modelling the effects of anisotropy in gas injection tests on boom clay) to the attendees.

Benefits

The applicant received valuable feedbacks from the attended professors, and also learned knowledge from others' posters.

Limitations

The space of a poster was limited, so only the most important results were presented, and detailed information was not shown.

Applicability

From the feedbacks, the applicant learned more about the details of how the experiment was performed, and it enables the applicant to improve the his model and simulate the experiment more closely to reality.

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

Multi-scale modelling approach

Description

Some examples of multi-scale modelling approaches for gas migration problems were presented during the lectures.

Usage

The applicant learned the concept of multi-scale modelling approaches, and got preliminary understanding of conceptualizing a multi-scale model.

Benefits

The applicant worked on the topic of gas migration in clay, which is highly affected by the changes of microstructures of the clay. Getting to know the multi-scale modelling approaches inspired the applicant to develop a model taking into account the influences of the microstructure of the material on gas migration behaviors.

Limitations

Due to course time constraints, it's not enough to understand details of the approach

Applicability

With the inspiration, the applicant will be able to conceptualize and implement his own multi-scale model.

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

None

Description

Replace this entire field with a description of the implementation of this practice, technique, method, tool or system at the host organisation.

Usage

Replace this entire field with a description of your operation or study of this practice, technique, method, tool or system during the mission.

Benefits

Replace this entire field with a description of the benefits for implementing this practice, technique, method, tool or system.

Limitations

Replace this entire field with a description the limitations of this practice, technique, method, tool or system.

Applicability

Replace this entire field with a description of how this practice, technique, method, tool or system could be implemented in or adjusted to your home context.

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

None

Description

Replace this entire field with a description of the implementation of this practice, technique, method, tool or system at the host organisation.

Usage

Replace this entire field with a description of your operation or study of this practice, technique, method, tool or system during the mission.

Benefits

Replace this entire field with a description of the benefits for implementing this practice, technique, method, tool or system.

Limitations

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Applicability

Replace this entire field with a description of how this practice, technique, method, tool or system could be implemented in or adjusted to your home context.

3. MISSION FINDINGS AND CONCLUSIONS

3.1. Lessons learned and conclusions

The applicant attended the five-day EURAD PhD school. The topics of the lectures contain theoretical knowledge of thermo-hydro-mechanical (THM) coupling, advanced multiphysics modelling approaches, laboratory and in-situ THM and gas experiments. A poster session and a site visit are also included. The lessons learned and conclusions are drawn as follows:

1. After the lectures, the applicant further deepened the understanding of the THM processes in geomaterials, including the mechanical behaviors, mass flow behaviors and heat transfer behaviors.
2. The applicant learned a lot about the multiphysics modelling approaches, especially the concept of multi-scale modelling inspired the applicant to realize that considering the changes of microstructures of material in modelling is promising to explain the THM responses of clay subjected to gas injection.
3. In the poster session, the applicant discussed his current work with the professors present, and received valuable feedbacks from them, which is very helpful for the applicant to improve his model. The applicant also got knowledge from other attendees' posters.
4. From the lectures of advanced multiphysics experimental testing, the applicant learned a lot the cutting-edge results and knowledge of gas migration problems, including the THM responses of clay in gas injection test, and the effects of gas migration on the clay microstructures and properties. Enriching knowledge of experimental observation enables the applicant to understand what is important to consider in modelling to reproduce the gas migration processes
5. The site visit to the HADES underground research laboratory gave the applicant a valuable chance to stay closely to the real testing facilities of radioactive waste disposal, and to understand how the in-situ THM and gas experiments are performed.

3.2. Relevant findings and conclusions for home organisation

This section is not mandatory but can be prepared with the mission supervisor or mentor from your home organisation. If applicable, replace this entire field with a description of about 200 words of findings and conclusions that are specifically relevant to your home organisation. If not applicable, remove the entire section.

3.3. Relevant findings and conclusions for host organisation

This section is not mandatory but can be prepared with the mission supervisor or mentor from the host organisation. If applicable, replace this entire field with a description of about 200 words of findings and conclusions that are specifically relevant to the host organisation. If not applicable, remove the entire section.

3.4. Relevant findings and conclusions for other organisations

This section is not mandatory but can be prepared with the experts from other organisations. If applicable, replace this entire field with a description of about 200 words of findings and conclusions that may be of particular relevance to other identified organisations or types thereof. If not applicable, remove the entire section.

4. POTENTIALS FOR IMPROVEMENT OR DEVELOPMENT

4.1. Generic potentials

This section is not mandatory. If applicable, replace this entire field with a description of about 150 words of generic potential improvements or developments you can suggest for the practices, techniques, methods, tools or systems operated or studied during the mission. If not applicable, remove the entire section.

4.2. Potentials for home organisation

This section is not mandatory but can be prepared with the mission supervisor or mentor from your home organisation. If applicable, replace this entire field with a description of about 150 words of specific potential improvements and developments you can suggest for your home organisation. If not applicable, remove the entire section.

4.3. Potentials for host organisation

This section is not mandatory but can be prepared with the mission supervisor or mentor from the host organisation. If applicable, replace this entire field with a description of about 150 words of specific potential improvements and developments you can suggest for the host organisation. If not applicable, remove the entire section.

APPENDICES

Mission journal

The daily activities carried out during the mission are described as follows:

Day 1: Lectures about theoretical knowledge

In the morning, Prof. F. Collin gave a lecture. The following contents were introduced: the engineering background of radioactive waste disposal, concepts of THM coupling, the governing equations and the constitutive laws of mechanical beheviors, liquid transport, and heat transfer, water retention curves, and other state equations. In the afternoon, Prof. Alessio Ferrari gave a lecture about experimental testing of geomaterials. The idea of experiment test, basic test approaches, and multiphysical testing approaches were introduced.

Day 2: Lectures about constitutive modelling

In the morning, Prof. Jean-Michel Pereira gave a lecture about constitutive modelling of geomaterials, including elasticity, plasticity, damage, and failure. In the afternoon, Prof. Olaf Kolditz introduced OpenGeoSys (OGS), a numerical framwork performing thermohydro-mechanical-chemical (THMC) processes in porous and fractured media, and showed how to develop and maintain numerical code.

Day 3: Poster presentation and lectures about experiment testing

In the morning, the applicant presented a poster 'Modelling the effects of anisotropy in gas injection tests on boom clay' and discussed with the professors and students present. In the afternoon, several lectures were given about advanced multiphysics experiment testing on geomaterials. Several types of gas injection test on clay and detection methods (e.g. micro-CT, imaging) were introduced, and the the effects of gas migration on clay properties (e.g. changes of pores size distribution, hydro-mechanical properties) were shown in details.

Day 4: Lectures about numerical modelling

In the morning, several lectures were given about multiphysics modelling in geomaterials. The concept of multi-scale modelling and a framework developed by UGA was introduced. Another case of multi-scale modelling taking into account the micro structure of the clay was introduced by Prof. F. Collin. The ability of the model to reproduce the HM responses of clay subjected to gas injection was shown in details. In addition, a method from TU Delft called 'FEM+Z', with zero-thickness interface element able to explicitly capture the gas-induced fractures was introduced.

Day 5: Site visit

Visit to the Tabloo expositions and EURIDICE_HADES underground research laboratory.

Mission bibliography

This section is not mandatory. If applicable, replace this entire field with an APA formatted list of the most relevant references to specific papers, reports etc. you identified when preparing the mission or during its course. If not applicable, remove the entire section.

MISSION BENEFICIARY

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PARTNER EXPERTS CONTRIBUTING TO THE MISSION

Host organisation experts

- Dr. Frédéric Collin, Professor, Department of Architecture, Geology, Environment & Constructions (ArGEnCo), University of Liège

Home organisation experts

- Dr. Anne-Catherine Dieudonné, Assistant Professor, Department of Civil Engineering and Geosciences, TU Delft
- Dr. Joaquín Liaudat, Postdoc Researcher, Department of Civil Engineering and Geosciences, TU Delft

Other organisations experts

- Dr. Alessio Ferrari, Research Associate, Soil Mechanics Laboratory, EPFL
- Dr. Jean-Michel Pereira, Professor, Ecole des Ponts ParisTech
- Dr. Olaf Kolditz, Head of Department Environmental Informatics, Helmholtz Centre for Environmental Research – UFZ
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- Dr. Pierre Bésuelle, Director of Research, National Centre for Scientific Research

REPORT APPROVAL

Date	Beneficiary	Home mentor/supervisor	Host mentor/supervisor
Date of last signee	Zhaojiang Huang	Dr. Anne-Catherine Dieudonné	Name
	Zhaojiang Huang