MOBILITY MISSION REPORT

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MISSION TITLE

Thermo-hydro-mechanical processes and geomaterials used in deep geological repositories

DESCRIPTION

Concerned organisations

- Research entities: CIEMAT (TSO)
- Waste management organisations: ENRESA

Concerned infrastructures or facilities

- Underground research laboratories
- ENRESA
- CIEMAT laboratories

Concerned phases

This field does not apply because no facility is going to be constructed. The aim of this mobility mission report is to emphasize what I have learned in the course of thermo-hydro-mechanical behaviour of bentonites taking place at the University of Liege.

Themes and topics

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

- Spent Fuel and high-level waste disposal canisters
- Containers for long-lived intermediate and low level wastes
- Clay-based backfills, plugs and seals
- EBS system understanding

Theme 4: Geoscience to understand rock properties, radionuclide transport and long-term geological evolution

- Long-term stability (uplift, erosion and tectonics)
- Perturbations (gas, temperature and chemistry)
- Aqueous pathways and radionuclide migration

Keywords

Gas transfer; Coupled processes; Geomaterials; Modelling; Water content; dry density; THM behaviour; bentonite

EXECUTIVE SUMMARY

It is crucial to understand the thermo-hydro-mechanical (THM) behavior of bentonites in various engineering and geological applications, especially in the context of nuclear waste repositories.

Bentonites are known for their remarkable swelling capacity when they come into contact with water. This swelling behavior is a fundamental aspect of THM behavior. The degree of swelling is influenced by factors such as temperature, moisture content, and the presence of salts or other ions in the surrounding environment.

The studies that I will conduct in CIEMAT ara focused on permeability and swelling processes. Bentonites typically exhibit low permeability, making them suitable for use as barrier materials in waste containment systems and other applications. THM studies help assess how permeability changes under different temperature and hydraulic conditions, which is crucial for long-term performance predictions. Bentonites can exhibit time-dependent behavior, such as creep and consolidation under load. THM studies help characterize these processes and provide insights into how bentonites respond to long-term stress and temperature changes.

I have been working in CIEMAT since February 2023 in the group of THM-G of barrier materials. In order to get deeper understanding of thermo-hydro-mechanical processes in geomaterials to help my research on the use of clay for deep geological repositories I attended the training course « Multiphysics and multiscale coupled processes in geomaterials. Focus on thermal effects and gas transfer impact on the behaviour of geomaterials. » from 28th of August to 1st of September in 2023. This course took place in the University of Liege, Belgium.

1. MISSION BACKGROUND

I will explain in this section the mission background:

1.1. R&D background

I have been working at CIEMAT in the group of Thermo-hydro-mechanics and geochemistry of barrier materials since February 2023. This group participates in the EURAD project, WPs GAS and HITEC. Hence, I attended the course "Multiphysics and multiscale coupled processes in geomaterials. Focus on thermal effects and gas transfer impact on the behaviour of geomaterials" in order to get a deeper understanding of this area of knowledge in which I shall work for the next 4 years.

1.2. Mission objectives

• Analysis of hydraulic and mechanical properties of bentonite (permeability, swelling, retention capacity), directing the performance of laboratory tests and interpreting them.

• Carrying out measurement analysis of permeability and swelling capacity in materials.

• Analysis of the effect of temperature on hydro-mechanical properties of drill cores and clay materials.

• Design and performance of tests to identify the effect of temperature rise on the rock mass and in the engineering barrier on its mineralogical and geochemical composition and its hydraulic and mechanical properties

1.3. Mission request

As I mentioned before the mission request is to attend the course "Multiphysics and multiscale coupled processes in geomaterials. Focus on thermal effects and gas transfer impact on the behaviour of geomaterials" in order to get a deeper understanding of this area of knowledge.

1.4. Mission composition

Host organisation

EURAD

Host facility

ULiege (Sart-Tilman campus), Liege, Belgium.

Mission dates

28 August – 1 September 2023, Liege (BE)

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

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

THM behaviour of bentonites in saturated conditions. Lecture “Basic of THM processes in geomaterials”

Description

The THM behaviour of bentonites was the main topic during the first day of the training course.

Usage

This is typically used for creating barriers for radioactive waste disposal.That is what the researchs carry out in CIEMAT are about.

Benefits

Understanding the behaviour of bentonites in saturated conditions will help me to carry on experiments in CIEMAT in the future.

Limitations

Not applicable.

Applicability

The knowledge learned in this lecture will help me in my future research.

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

Modelling the THM behaviour of bentonites. Lectures “Constutive modelling of THM processes in geomaterials” and “Development, validation and maintenance of numerical codes”

Description

The modellinf of THM behaviour of bentonites was the main topic during the second day of the training course.

Usage

Modelling THM behaviour of bentonites is necessary to visualize its impacts in order to build nuclear waste repositories in the future.

Benefits

Undersating the use of software as OpenGeoSys is hepful to deepen study the behaviour of bentonites.

Limitations

I do not have experience in this field. My background it is not related with modelling and computing so it was not easy to follow the lecture.

Applicability

My department does not carry out modelling of THM behaviour so I am not sure if I will use this software I the future but It was really pleasant to get to know more about the behaviour of bentonites from a different approach of expertise.

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

Gas transport and bentonites – Lecture " In situ THM and gas experiments"

Description

Gas transport was the main topic of the lecture "In situ THM and gas experiments" during the fourth day of the training course.

Usage

Bentonite´s behaviour is crucial for controlling gas transport. So, this will help me to understand better its behaviour ir order to carry out my future researchs.

Benefits

Currently, I do not work with gas experiments but this has helped me to understand better the properties of bentonites. Besides, the group in which I work owns a gas transport facility, so I may apply this knowledge in the future.

Limitations

Due to my background I have no previous knowledge about the matter so it was not easy to follow.

Applicability

Currently my group is carrying out some experiments about gas transport but I am not part of them for the moment, although the knwolege gained may be useful in the future

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

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Description

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Usage

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Benefits

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Limitations

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Applicability

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3. MISSION FINDINGS AND CONCLUSIONS

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3.1. Lessons learned and conclusions

This course has helped me understand the THM behaviour of bentonites better. My studies in Spain mainly focus on MX80 and FEBEX bentonite. However, in this course, I learned about the behaviour of other materials such as Boom clay and Opalinus clay. Additionally, I have learned about how different countries such as France, Belgium, Italy and Switzerland are planning to store their nuclear waste in the future with different approaches of multibarrier concept.

Furthermore, this course has provided me with knowledge of modelling THM processes that I was not familiar with before the course. Modeling THM processes in geomaterials involves developing mathematical and numerical models that describe how these clay materials respond to variations in temperature, water content, and mechanical loading. There was an interesting lecture about the use of OpenGeoSys, which is a software capable of simulating THMC processes using a bench from the gallery. I might use this software in the future in my research.

Overall, the THM behaviour of bentonites is a complex and multidisciplinary field of study because it involves the interplay of thermal, hydraulic, and mechanical processes, as well as chemical reactions and microstructural changes. Bentonites are highly sensitive to temperature changes. An increase in temperature typically leads to increased hydraulic conductivity, reduced water retention capacity, and altered mechanical properties. Research in this area is essential for ensuring the safe and effective use of bentonites in various engineering and geological applications.

3.2. Relevant findings and conclusions for home organisation

Not applicable

3.3. Relevant findings and conclusions for host organisation

Not applicable

3.4. Relevant findings and conclusions for other organisations

Not applicable

4. POTENTIALS FOR IMPROVEMENT OR DEVELOPMENT

Not applicable

4.1. Generic potentials

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4.2. Potentials for home organisation

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4.3. Potentials for host organisation

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APPENDICES

Mission journal

The mission consisted of attending to a course focused on THM processes in geomaterials during one week in the University of Liege as a part of the phD school of EURAD WP GAS AND WP HITEC. A description of the daily activities is as follow:

Monday, August 28th:

There were two lectures. The first one was about the basics of THM processes in geomaterials focusing on a comparison between saturated and unsaturated conditions and how it affects the behaviour of bentonites. It also discussed how it produces hystereis effects between dry and wet phase. The second one was focused on the experimental testing regarding parameters such as the representative elementary volume, the total stress and the stiffness in order to know what we control and what we measure while testing.

Tuesday, August 29th:

During these lectures, we learned about modeling THM processes in geomaterials. This lecture was focused on understanding of the mathematics equations used in soil studies, and they also talked about OpenGeoSys (a free-online software) and taught us some commands used in this software in order to generate THMC models.

Wednesday, August 30th:

During the morning we had the chance to listen to phD students discussing their researchs and presenting their posters. Additionally, we could network and ask the PhD students for their findings. In the afternoon there were three different lectures focused on different bentonites and different approaches to deep geological repositories depending on the country (Spain, Belgium and France).

Thursday 31 of August:

In these lectures, we delved into advanced multiphysics modelling of geomaterials related to what we had learned in the previous lectures. During the afternoon we learned about in situ THM and gas experiments such as the one taking place at CIEMAT related to FEBEX bentonite.

Friday, September 1st:

During this day we visited the HADES underground research laboratory and the Tabloo exhibitions about nuclear power and nuclear waste management.

MISSION BENEFICIARY

Natalia Gimeno
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PARTNER EXPERTS CONTRIBUTING TO THE MISSION

Host organisation experts

Not applicable

Home organisation experts

María Victoria Villar, researcher, Department of Environment, CIEMAT

Other organisations experts

Not applicable

REPORT APPROVAL

Date	Beneficiary	Home mentor/supervisor	Host mentor/supervisor
Date of last signee	Natalia Gimeno	María Victoria Villar	Not applicable
	Visa Firmado	Visa Firmado	Visa