TIMODAZ Second Training Course:
Impact of THMC processes on Performance Assessment
UPC, Barcelona, Spain, 13th – 15th January 2010

Course exercise proposal

Two reference designs for radioactive waste repositories in deep geological clay formations (OPA/Bentonite & BC/Concrete) are provided and briefly explained (how the systems are supposed to fulfil their safety functions)
Participants with a geomechanics and/or PA background will work together to:

1. **Identify TIMODAZ results (from tutors' presentations) that can be used in the context of a safety case and propose how to treat these:**
   - concepts (anisotropy, thermo-plasticity,...)
   - supporting pheno evidence (self-sealing, upscaling,...)
   - predictive capability of models
   - ...

The main issues to be addressed by the working groups are:

- Understanding of key processes and mechanisms driving the **THMC evolution** of near-field of repository system (key topics for this training course in **bold**)
  - THMC evolution of barriers
    - **Natural barrier (host formation)**
    - Engineered barriers
  - **DZ evolution**
    - **During thermal period**
    - Long-term evolution (chemical degradation, creep, …)
  - Interfaces

- Identification and characterisation of relevant processes and mechanisms
  - Through lab testing
  - Through in situ testing
  - Lessons learnt from experiments
  - Interpretive modelling

- Application in the context of a safety case for a deep repository
  - Predictive capabilities of modelling
  - Integration in PA
  - Substantiation of the safety statements
  - Feedback to repository design

The working groups may try to complete a table looking like Table 1 in order to describe the sequence of events and processes driving the evolution of the near-field of the repository system.

Table 1: Example of table describing the THMC evolution of the near field and giving the state of the art

	Disposal history	Indurated clays	Plastic clays
↓ THMC evolution	Initial state - key features (phenomenological) - key features (with safety in mind) - lessons learned from experiments		
	Construction phase - key processes - lessons learned from experiments - predictive capabilities of modelling - PA issues		
	Exploitation phase - key processes - lessons learned from experiments - predictive capabilities of modelling - PA issues		
	Early closure phase - key processes - lessons learned from experiments - predictive capabilities of modelling - PA issues		
	Long-term post-closure phase - key processes - lessons learned from experiments - predictive capabilities of modelling - PA issues		
	……..		

Special attention will be given to:

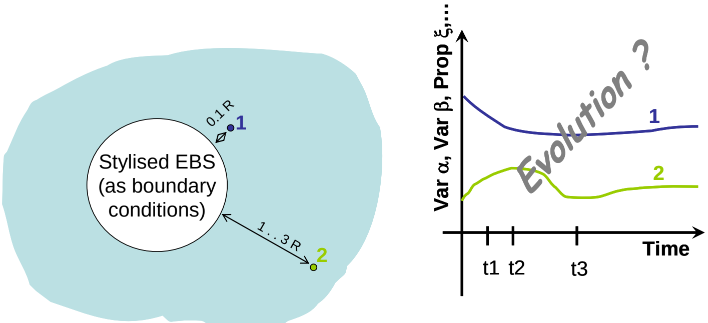
- the identification of thermal, hydraulic mechanical and chemical conditions that can alter the favourable properties of the host clay during the thermal period;
- the conditions under which the changes can become irreversible (*i.e.* under which conditions will the future properties of the host clay differ from the currently observed properties?);
- the extent to which temporary or permanent alterations of favourable properties of the host clay can really affect the individual barrier and safety functions of the system (*i.e.* to which extent can these alterations be significant from a Performance Assessment (PA) point of view?);
- the main uncertainties and the way to treat these in the context of a safety case.

Specific topics could be:

- similarities (and differences) between potential host clays;
- transferability of knowledge gained on one site or host clay to another;
- understanding of observed fractures around URLs;
  - role of in situ stresses
  - role of material anisotropy
  - …
- how to address experimental limitations;
- interactions between the thermal perturbation and other perturbations (gas,…);
- temperature influence on the three conditions that can compromise diffusion-dominated transport:
  - high permeability
  - sufficient supply of water
  - driving force
- effect of initial and boundary conditions imposed by construction techniques, EBS designs and operation strategies, potential for optimisation;
- …

2. Build a storyboard of the expected evolution of the disturbed zone up to (at least) the end of the thermal period

- Expert judgement exercise[1]: the groups will attempt a qualitative description of the expected evolution of key state variables and properties at selected locations in the near field (see Fig. below). This exercise will be carried on:
  - for both indurated and plastic clays;
  - under stylised boundary conditions (for instance, backfilling with a very high suction potential versus a backfill imposing little or no suction);



- The results of the different working groups will be compared
- The comparison should reflect in some extent the capability to estimate the near-field evolution
- Conclusions of the working group.

[1] Such an exercise was also conducted during the THMC Conference & Workshop held in Luxembourg, 29 September – 1st October 2009 and led by the chairmen, lecturers and rapporteurs of the Clay, Salt and Crystalline & Buffer Working Groups. The results will be published soon in the proceedings of this event.

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Supporting material for Course Exercise: Expected Evolution Questionnaire

Yesterday, you have been provided with a background about typical geological repository designs and the way these systems are supposed to work to ensure the long-term safety of radioactive waste disposal. For such repositories, a Safety Case has to argument that the disposal system is safe and that its long term evolution is sufficiently understood. For the Course Exercise, it might be helpful to complete this short questionnaire on the expected **evolution** of the clay and especially the damaged zone around a disposal system, based on the R&D results (lab tests, in situ tests, modelling) that have been discussed this morning.

Q1: As the conditions within and around the repository change, for example:

- during the construction & open drift period (drainage, ventilation, oxidation…);
- at the time of waste emplacement (heating starts);
- after the closure (remaining cavities are backfilled, saturation of the engineered barriers begins);
- while temperatures in the near field (rapidly) increase;
- while temperatures in the near field (slowly) decrease;
- while the engineered barriers and the clay chemically interact;
- when finally, the engineered barriers fail,

What is your current idea about the expected evolution of the clay around a typical repository and especially the damaged zone, during the first 10,000 years? Please try to describe the evolution in plain English (simple sketches or graphs are acceptable). For instance, you may describe how pore pressures, stress paths or fractures are expected to evolve, but you may also focus on any other significant features that you think are important to understand the THM(C) behaviour of the system. Ideally your description of the evolution should not exceed **one** or at most **two pages** (sketches included !) so try to focus on the essentials.

My idea of the expected evolution is:

Please note:

- simplified, incomplete, qualtitative answers or just evolution trends are perfectly OK !
- Your answers may be generic (evolution trends that are common to all clays) or limited to a specific clay formation and/or a specific set of processes you are familiar with.
- If needed, you can chose unspecified boundary conditions as appropriate to you.
- The purpose of this questionnaire is to take a snapshot of what we collectively believe could be the evolution of the system. It is not a problem if, later in the project, we are proved to be wrong.

(Expected evolution, continued)

(Expected evolution, continued)

Q2: What are, in your opinion and given today's available knowledge, <u>the largest uncertainties</u> about the expected evolution of the clay around a typical repository and especially the damaged zone? (Please answer in 5 lines maximum.)

Q3: Which <u>specific aspect(s)</u> of the above evolution or uncertainties would <u>your</u> experiments or modelling efforts be addressing in priority? How? (Please answer in 5 lines maximum.)

Thank you for completing this questionnaire !