European Joint Programme on Radioactive Waste Management

Influence of temperature on clay-based material behaviour EURAD WP7 – HITEC

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EURAD - *European Joint Programme on Radioactive Waste Management*

- EURAD
  - Coordinator = Andra (France), Marie Garcia
  - Started June 2019
  - EC budget 32.5 M€ budget for 5 years
  - Co-funding requirement at 50% for R&D activities at national level

- HITEC - Influence of temperature on clay-based material behaviour
  - A work package of EURAD
  - Aim: Improved Thermo-Mechanical description of clay based materials at elevated temperatures
  - WP leader = VTT(Finland), Markus Olin
  - EC budget 2.5 M€

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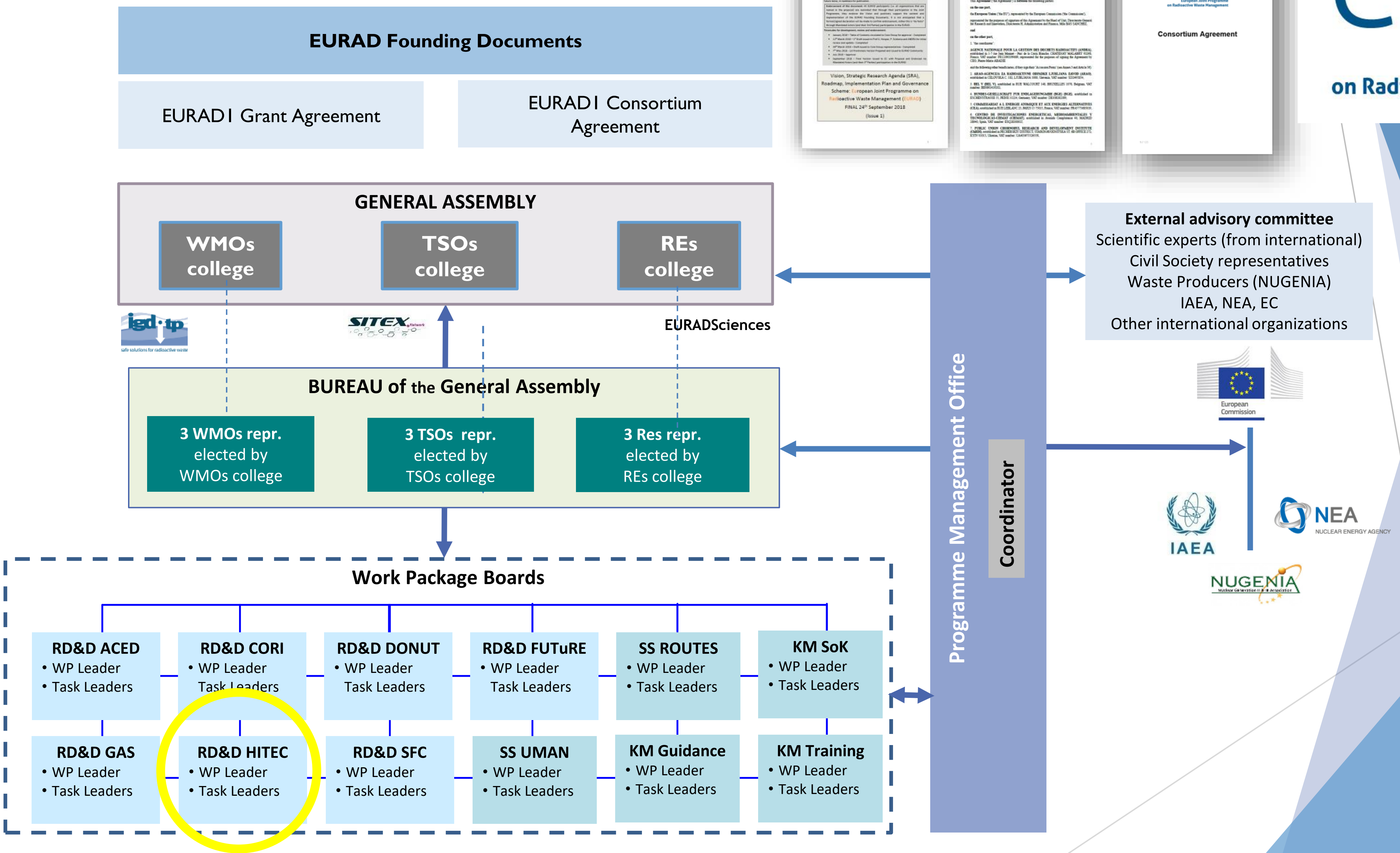
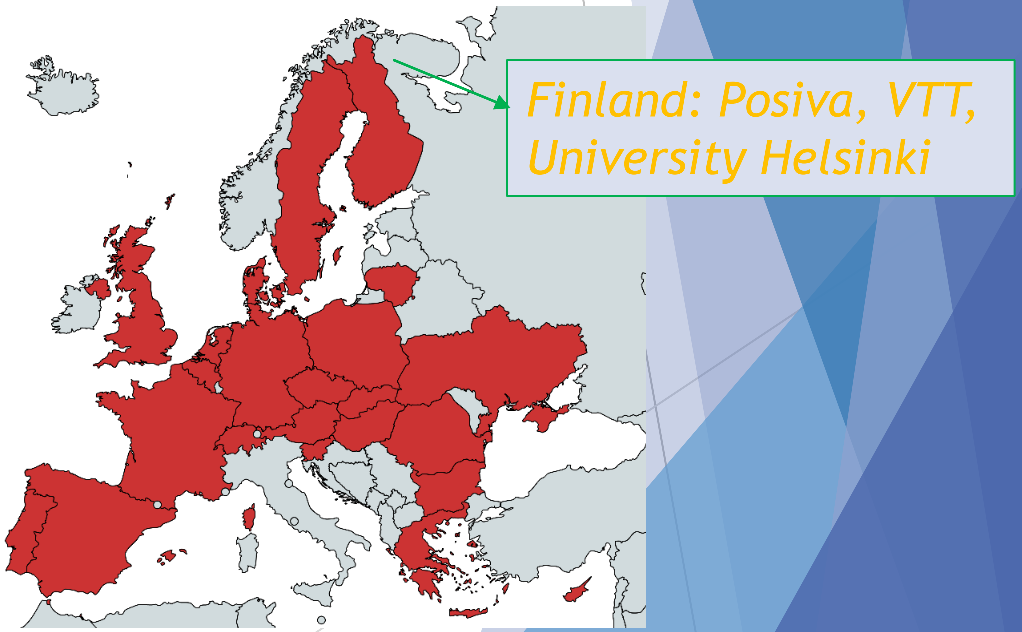


EURAD Participants

- **Ministries** from **23 European countries** (21 MS and 2 Associated countries) provided **mandates** to those actors acting as **Beneficiary** within EURAD, recognising their role of directing RD&D at national level either as **WMO (Waste Management O)**, **TSO (Technical Support Organisations)** or **RE (Research Entities)**. Research entities group
  - 53 Mandated Organisations (***Beneficiaries***)
    - 20 WMOs
    - 13 TSOs
    - 20 REs
  - 56 organisations linked to a Mandated Organisation (***Linked Third Parties***)
    - Mainly research entities, consulting groups



WP 7 - HITEC: Who?

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WP 7 – HITEC: Topics

- **Task 1 - S/T coordination, State-of-the-art and training material**
  - Task Leader: VTT – Markus Olin
  - SoA: CIEMAT – Maria Villar
  - Training: Uliège – Robert Charlier
- **Task 2 - Clay host rock <120°C**
  - Task Leader: Ulorraine – Dragan Grgic
  - T2.1: Ulorraine - Dragan Grgic
  - T2.2: BGS – Katherine Daniels
  - T2.3: Andra – Gilles Armand
- **Task 3 - Clay buffers >100°C**
  - Task Leader: CTU – Jiří Svoboda
  - T3.1: SKB - Daniel Svensson
  - T3.2: BGS - Katherine Daniels
  - T3.3: CIEMAT - Maria Victoria Villar
- **Task 4 - Impacts and deployment of results**
  - Task Leader: VTT – Markus Olin
  - T4.1: NAGRA – Olivier Leupin





WP 7 – HITEC: Why?

- T2 Clay host rock
  - The overpressure generated by the difference between thermal expansion coefficient of pore water and the solid rock skeleton may have deleterious consequences.
  - In far field, this could induce rock damage and reactivate fractures/faults.
  - In near field characterized by a fractured zone, this could induce fracture opening or propagation in this fractured zone, altering the permeability.
- T3 Buffer bentonite
  - Proving that higher temperatures than presently accepted are suitable is very relevant even for current concepts.
  - It increases safety margin and gives greater credibility to the design (e.g. if it is proven to work for 130°C then for 100°C it is definitely safe).

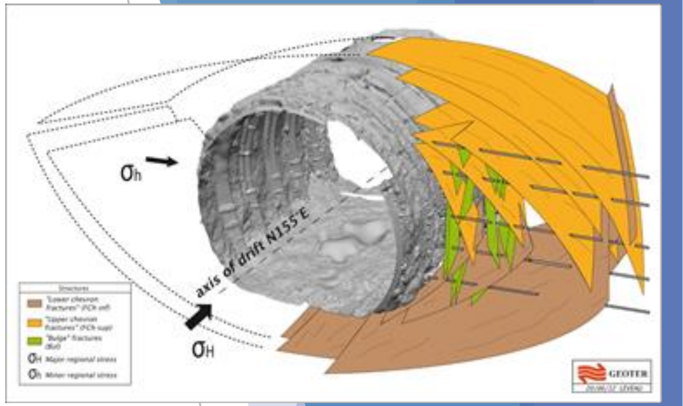
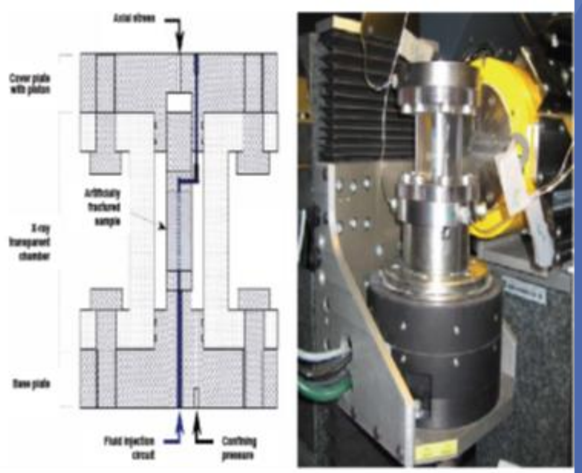


Figure: Andra



HITEC - Main Objectives

- Briefly: **Improved THM (Thermo-Hydro-Mechanical description of clay based materials at elevated temperatures - no C yet**

1. To evaluate whether an increase of temperature is feasible and safe by applying existing and novel knowledge about clay materials at elevated temperatures:
   a) to improve understanding of the THM behaviour of clay rock and clay buffer under high temperature and provide suitable THM models,
   b) to better assess effect of overpressures on the THM behaviour and properties of the clay host rock, and
   c) to identify processes at high temperature and the impact of high temperature on the THM properties of the buffer material.

HITEC - Main Objectives 2

2. Host clays formations: to deploy knowledge to mechanics of clay to better evaluate/model possible damage evolution.
3. Buffer bentonite: to deploy knowledge to hydro-mechanical behaviour at high *T*.
4. To document all the above to be utilised in Safety Cases studies
   I. Mechanical properties, swelling pressure, hydraulic conductivity, while the integrity of the clay may be evaluated as changes in mineralogy, chemical content or physical integrity of the compacted blocks.
   II. The safety functions and the overall integrity of the bentonite and/or clay host rock will be evaluated after a high temperature exposure.
5. To assure interaction between CSO and participants of the WP

HITEC - Expected impacts

- Regarding RWM implementation needs
  - Important to assess the consequences of the high *T*
  - Most of safety cases limit maximum temperature to 100°C: Higher temperatures can have significant advantages: higher enrichment/burn-up fuels, interim storage requirements, (re)packaging of the waste, reducing footprint of the disposal
- Regarding safety case concerns
  - Knowledge about utilising higher temperatures, setting up limits of temperature and which kind of overall impacts higher temperatures causes to materials and systems.
  - Proving that higher than present temperatures are acceptable is very relevant even for current concepts:
- Regarding increasing scientific and technical Knowledge
  - There is now only limited knowledge about the clay mechanics at higher than 100°C - increase scientific and technical knowledge.

What?

- State-of-the-art:
  - a synthesis of the state of knowledge on the THM behaviour of different buffer materials at different temperatures. A focus has to be made on data obtained over 100°C;
  - a synthesis of the state of knowledge on the THM behaviour of host claystone (Boom clay, Opalinus Clay, Callovo Oxfordian claystone). The effect of temperature in near field on the EDZ (extension, permeability properties, self-sealing processes …) and in far field on the thermal pressurization.
- Training:
  - In January 2020 and (M42) common graduate school with GAS WP
- Task 4.1: Guidance for safety case development and repository optimization – NAGRA

- T2 Clay host rock
  - **Subtask 2.1** will use lab experiments to assess a possible extension of the excavation induced fracture network, investigating the role of the fracture network on the containment properties of the host rock.
  - **Subtask 2.2** will also use lab experiments on materials at elevated temperatures, and will focus on the thermal pressurisation and the risk of damage when the effective stress increases up to the overburden weight.
  - **Subtask 2.3** will focus on the development of THM models which are able to consider processes studied in subtasks 2.1 and 2.2.
- T3 Buffer bentonite
  - **Subtask T3.1**: Material subjected to the high temperature will be studied and changes of properties will be determined. Both laboratory treated material and samples from (in-situ) experiments are included.
  - **Subtask T3.2:** Investigation of processes and material behaviour at higher temperatures/transients.
  - **Subtask T3.3:** Experiment designed to simulate processes in clay buffer at various level of complexity. These experiments create basis for system behaviour understanding and database for mathematical model validation. Conceptual development of mathematical models. Validation by data from T3.1 and 3.2.

Risks

- Highest risk are in high temperature measurements, which will be technically challenging.
  - Careful planning is necessary in order to observe, avoid and mitigate any issues early on
- Rather many organisations (30) participating. However, coordination must be carried out with very limited resources.
  - WP Board working to be organised in very effective way
- Not enough parameter data at high temperature available for modellers
  - Deploying effectively available material and HITEC's own results, coordination between experimental and modelling teams

Conclusions:

- Clay based materials are important components in many final disposal concepts
- High level waste and spent nuclear fuel produce heat – production decreasing as a function of time
- The dimensioning of the repository is mostly based on keeping the maximum temperature at required level e.g. under 100 ºC
- Material behaviour should be known better at higher temperature, too

1. Analysing uncertainty of present concepts
2. Studying the possibility for safe accpeptance of higher temperatures – optimisation and/or industrialisation of the concepts