WP7 - Influence of temperature on clay-based material behaviour (HITEC)

Markus Olin/VTT, Berlin, 3-4 December 2018

Content of presentation

1. WP Main Objectives
2. WP Expected impacts
3. WP Participants
4. WP – Task Breakdown and WP Board
5. WP – Planned resources
6. WP – Tasks' descriptions
7. Key challenges and objectives in the first year – to communicate near-term focus

HITEC - Main Objectives

- Briefly: **Improved THM 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.

HITEC Participants

Organisations
✓ **Andra**, France (WMO) ▪ BRGM, France
✓ **BGE**, Germany (TSO)
✓ **CEA**, France (RE) ▪ EDF, France
✓ **CHRDI**, Ukraine (WMO) ▪ KIPT, Ukraine ▪ SIIGNASU, Ukraine
✓ **CIEMAT**, Spain (TSO) ▪ UAM, Spain ▪ UPC, Spain
✓ **CNRS**, France (RE) ▪ ULorraine, France
✓ **ENRESA**, Spain (WMO)
✓ **IRSN**, France (TSO) ▪ NTW, France
✓ **KIT**, Germany (RE) ▪ BGR, Germany

Organisations
✓ **LEI**, Lithuania (RE)
✓ **NAGRA,** Switzerland (WMO)
✓ **ONDRAF/NIRAS**, Belgium (WMO) ▪ EURIDICE, Belgium ▪ ULiège, Belgium
✓ **POSIVA**, Finland (WMO)
✓ **SURAO**, Czech Republic (WMO) ▪ CTU, Czech Republic ▪ CU, Czech Republic ▪ UJV, Czech Republic
✓ **RWM**, United Kingdom (WMO)
✓ **SKB,** Sweden (WMO)
✓ **UHELSINKI**, Finland (RE) ▪ GTK, Finland ▪ JYU, Finland
✓ **UKRI-BGS**, United Kingdom (RE)
✓ **VTT**, Finland (TSO)

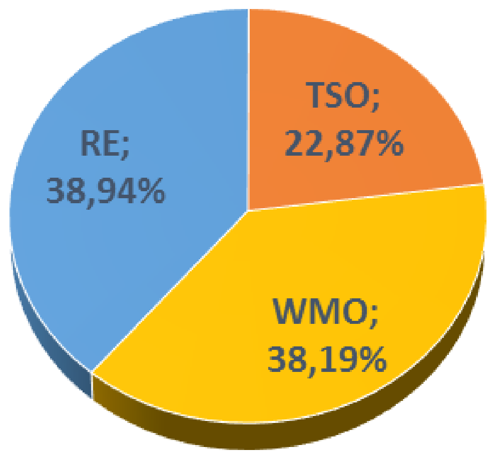
HITEC – Task Breakdown and WP Board

- **WP Leader**: Markus Olin, markus.olin@vtt.fi +358 400 477 244

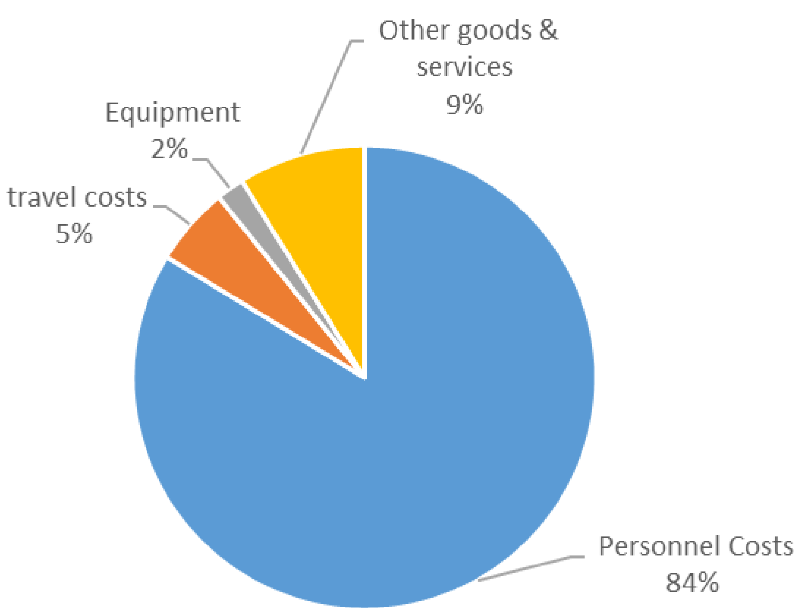
- **Task 1 – S/T coordination, State-of-the-art and training material**
  - Task Leader: **VTT**, SoA: CIEMAT, Training: ULiège
- **Task 2 - Clay host rock <120°C**
  - Task Leader: T2.1: CNRS (**ULorraine**), T2.2: KIT (**BGS**), T2.3: **Andra**
- **Task 3 - Clay buffers >100°C**
  - Task Leader: SURAO (**CTU**), T3.1: **SKB**, T3.2: KIT (**BGS**), T3.3: **CIEMAT**
- **Task 4 - Impacts and deployment of results**
  - Task Leader: **VTT**, T4.1: **NAGRA**
- **Task 5 - Civil Society interaction**
  - Task Leader: IRSN (**NTW**)

WP – Planned resources

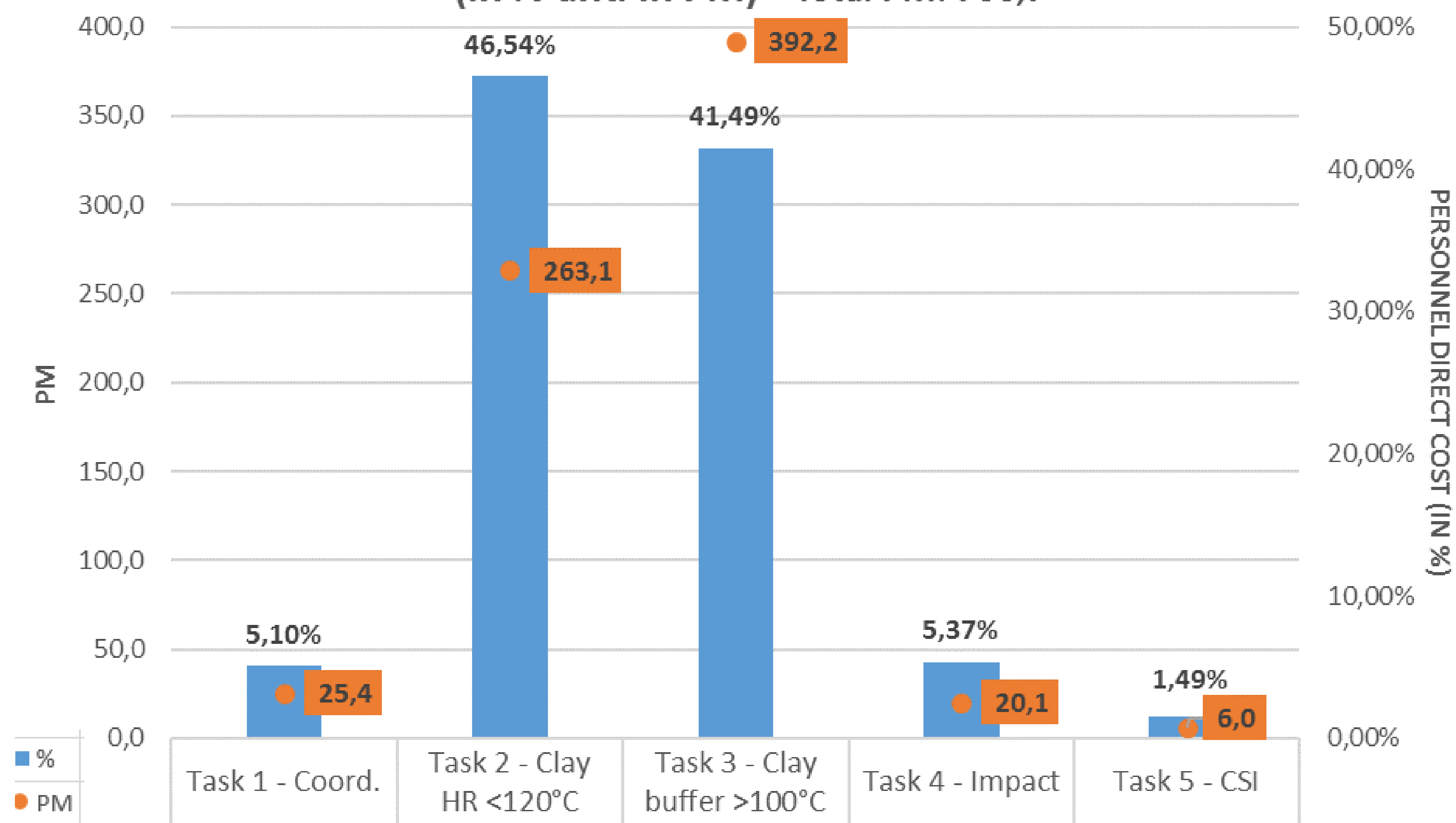
HITEC WP:
Distribution of EC Contribution between categories of Actors



HITEC WP - Budget distribution between categories of direct costs



HITEC WP:
Personnel costs breakdown per task
(in % and in PM) - Total PM: 706,7



HITEC – Task 1: Coordination, SoA & training

- Task 1 – Task Leader: **VTT**
  - Task 1.1 Coordination: VTT
  - Task 1.2 SoA: CIEMAT
    - State-of-the-art and existing data about clay materials at high temperatures: experimental procedure, processes, parameters and models available for the buffer material and host rock
    - Identifying existing or ongoing large-scale in situ experiments which can be proposed in Tasks 2 and 3 as benchmark exercises.
    - SoA report - D7.1 Month 7
  - Sub Task 1.3 Training material –Sub Task Leader: ULiège
    - To share the knowledge, mainly inside the HITEC and Gas WP.
    - Organize two doctoral schools / training workshops, of THM behavior and modelling
    - The 1st school at the project beginning, about month 6. The 2nd school at the end of the project, about month 42.
    - The 1st school will benefit from the doctoral school already organized during the Beacon project.

HITEC – Task 2: Clay host rock <120°C

- Task 2 - Task Leader: **CNRS** (ULorraine), T2.2: BGS, T2.3: Andra
- **Main objective:** increase knowledge on the THM behaviour of clay host rock
  - Task 2.1: experiments near field with EDZ
    - Assess through lab experiments a possible extension of the excavation-induced fracture network and permeability evolution.
  - Task 2.2: experiments on far field
    - Focus on the thermal loading and overpressures generated; risk of damage when the effective stress increases up to the overburden weight; impact of temperature on the self-sealing capacity of host rocks
  - Task 2.3: THM modelling of temperature effect in near and far field
    - Focus on the development of THM models which are able to consider processes studied in subtasks 2.1 and 2.2

Sub-task	**2.1 Near field**	**2.2 Far field**	**2.2 Far field**	**2.2 Far field**	**2.2 Far field**
Lab experiments	Self-sealing	Compression tests	Creep tests	Extension tests	Over pressure
Callovo Oxfordian claystone	BGS Georessources 3SR	Georessources	Georessources	CEA	BGS
Opalinus claystone	BGS Georessources	Georessources	Georessources CEA	CEA	BGS
Boom clay	BGS		CEA		BGS

HITEC – Task 2: Clay host rock <120°C

- Technical reports on thermal effects on near field properties (Task 2.1):
  - Dataset of self-sealing capacities, fracture propagation and mechanical properties of fractured media.
  - 1st version month 12, 2nd version month 24, final version month 46
- Specific GAS/HITEC technical report on self-sealing processes
  - 1st version month 12, 2nd version month 24, final version month 46
- Technical reports on effect of temperature on far field properties (Task 2.2):
  - Dataset of short-term and long-term thermo-mechanical properties, impact of thermal load on size and duration of overpressures generated and the material permeability.
  - 1st version month 12, 2nd version month 24, final version month 46
- Modelling reports on effect of temperature on near field properties (Task 2.3):
  - Model description, Benchmark description, Comparison of the model and Synthesis. -> T4
  - 1st version month 12, 2nd version month 24, final version month 46
  - Selection of benchmark exercises for task 2.3- month 9
- Experimental methodologies will take advantage of lessons learned from EC TIMODAZ and SELFRAC.

HITEC – Task 3: Clay buffers >100°C

- Task 3 - Task Leader: **CTU**

Main objective: Whether an increase of temperature is feasible and safe by applying existing and new knowledge about buffer at elevated temperatures

- Task 3.1: Characterisation of material treated by high temperature
  - Assessment of clay buffer subjected to high temperatures: investigate material changes
  - Determination of parameters necessary for mathematical modelling
- Task 3.2: Experiments at temperatures >100°C
  - How permeability, swelling and hydro-mechanics evolves under high thermal loads
  - Determination of parameters necessary for mathematical modelling (input into Task 3.3)
- Task 3.3: Small scale experiments, model development and verification
  - Calibration and development of suitable THM models for clay buffer at higher T
  - Objectives:

1) Understanding of processes at larger scale

2)Development and validation of mathematical models (at concept/element level)

3)Benchmark of available and developed codes to assess their suitability for high temperatures

HITEC Task 3: Clay buffers >100°C

- Materials characterization (Task 3.1, leader: SKB):
  - 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. Specific technical reports will be produced.
- Technical reports on thermal effects on clay buffer (Task 3.2, leader: BGS):
  - Dataset of short-term and long-term thermo-hydro-mechanical properties of the clay buffer; investigate the impact of heating above 100°C on permeability, swelling and hydro-mechanical behaviour.
  - 1st version month 12, 2nd version month 24, final version month 46
- Reports on thermal effects on clay buffer (Task 3.3, Leader CIEMAT):
  - Laboratory tests simulating conditions in the repository (hydration under thermal gradient); provide online information for THM model validation
- Interactions with EC projects or any other international actions
  - Experimental methodologies will take advantage of lessons learned from EC BELBaR and BEACON
  - Material will be acquired from in-situ experiments (ABM)

HITEC – Task 4: Impacts and results

- Task 4 - Task Leader: **VTT**
  - Task 4.1: Guidance for safety case development and repository optimization – NAGRA
    - The task will be based on the progress beyond the state of the art that was realized in Task 2 and Task 3 to develop guidance for the WMOs (**D7.11**). Individual WMOs, with safety cases already in place and optimization question being raised, will assess the impact for each of their specific safety cases and optimization targets (safety and cost). The guidance will aid all other programmes facing questions related to thermal dimensioning of the repository.
  - Tasks 4.2 Final reporting - VTT

HITEC – Task 5: Civil Society (CS) interaction

- Task 5: Task Leader: Nuclear Transparency Watch (NTW) Project and task aims for Civil Society (CS) interaction:
  - Facilitate the translation of scientific/technical results to allow effective interactions with CS;
  - Create the conditions for Civil Society Organisations to express their expectations and perspectives;
  - Improve the mutual understanding of how and to what extent an RD&D activity on RWM makes sense and contributes to improving decisions
  - Develop propositions on how to interact with CS on scientific and technical results and on how to interact with CS stakeholders
- Scoping of HITEC tasks 2-4, initial input from the CS experts and development of Interaction with Civil Society (ICS) action plan including topics of interest (M1-M12)
- Implementation of ICS action plan with work on topics within HITEC (M12-M36)
- Synthesis work and dissemination (M36-M48)

HITEC - Key challenges & objectives for Year 1

- Task 1: State-of-the-art report (Month 6)
- Task 2:
  - Task 2.1 – Select fractured samples, apparatus development, define loading conditions, first results from earliest tests obtained
  - Task 2.2 – Develop experimental apparatus and test plan, first results on short-term behaviour at lowest temperature provided to modellers
  - Task 2.3 – Select and prepare benchmark exercises, start to develop and update model
- Task 3:
  - Task 3.2 – Assemble experimental apparatus, acquire samples, develop test plan, obtain first results
  - Task 3.3 – Ensure a good connection between experimentalists and modellers and a test design that satisfies the modellers needs
- Task 5:
  - ICS Action Plan (Month 11)