The PRACLAY experiment at URL HADES in Mol, Belgium

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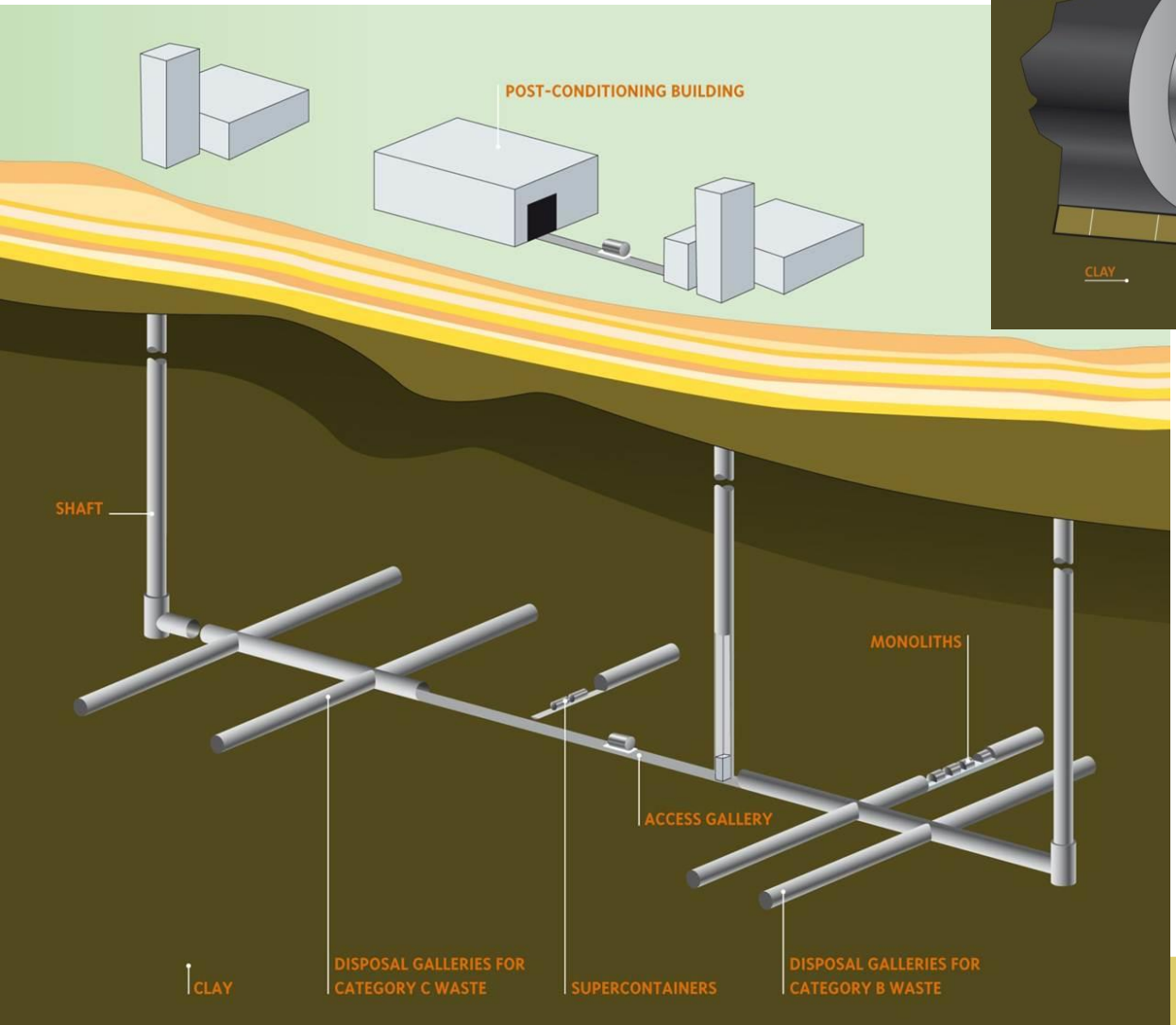
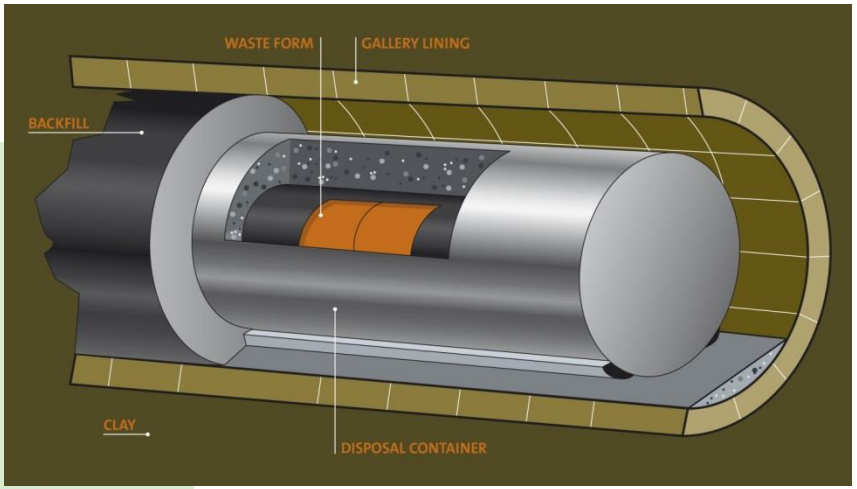
Outline

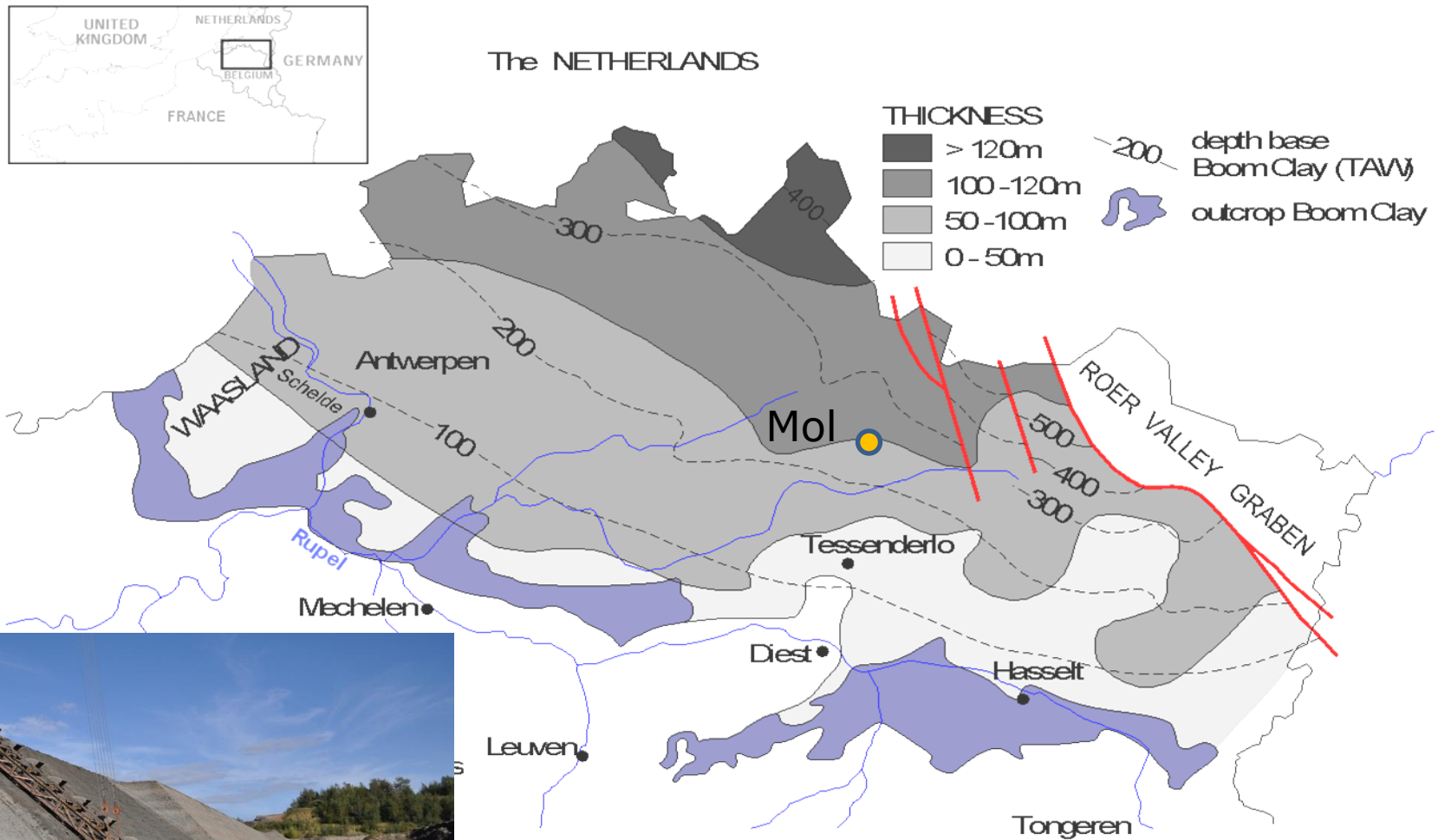
- Belgian concept of HLW geological disposal
- Boom Clay and URL HADES
- PRACLAY In-Situ Experiment
  - Gallery & Crossing test
  - Seal test
  - Heater test
- PRACLAY Heater test
  - Design
  - First results

Current design of geological disposal repository of HLW





Boom Clay : one of the potential Host Rocks

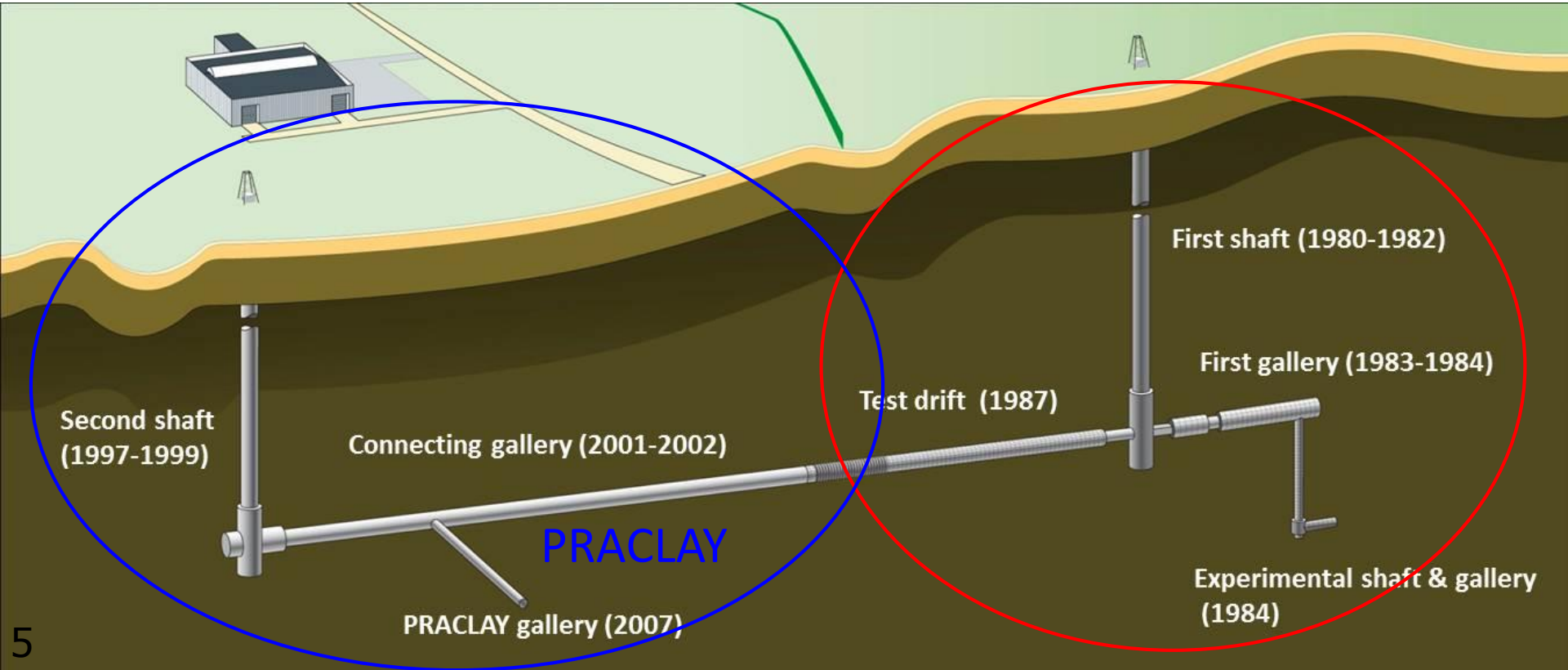


Plastic Clay

Kw : 3-6 x10^{-12} m/s

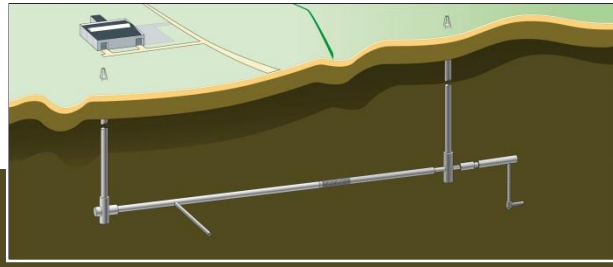
URL HADES (High-Activity Disposal Experimental Site)

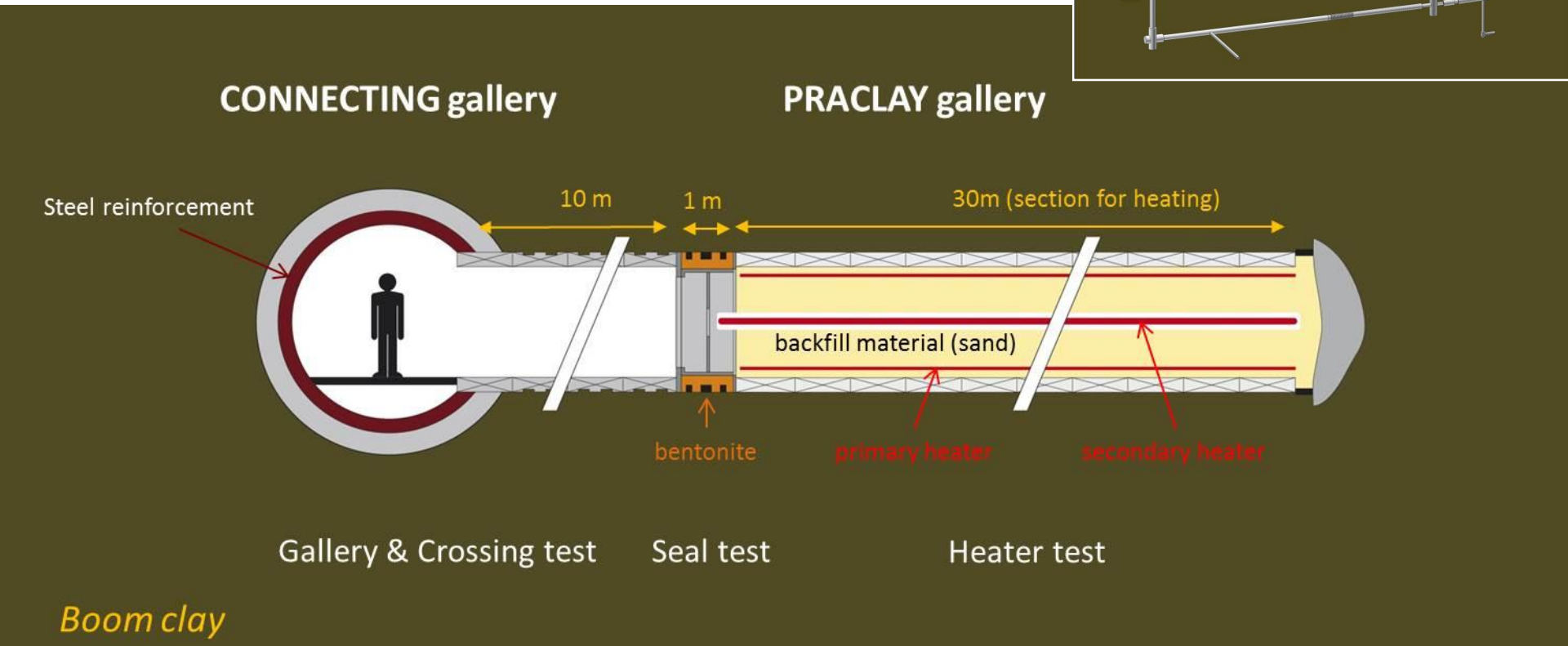
- Phase 1 1980 – Pioneering R&D
- Phase 2 1997 – Demonstration – Feasability
  - Confirmation of system understanding and safety
  - Demonstration in real scale and in situ of technical and industrial feasibility



PRACLAY In-Situ Experiment

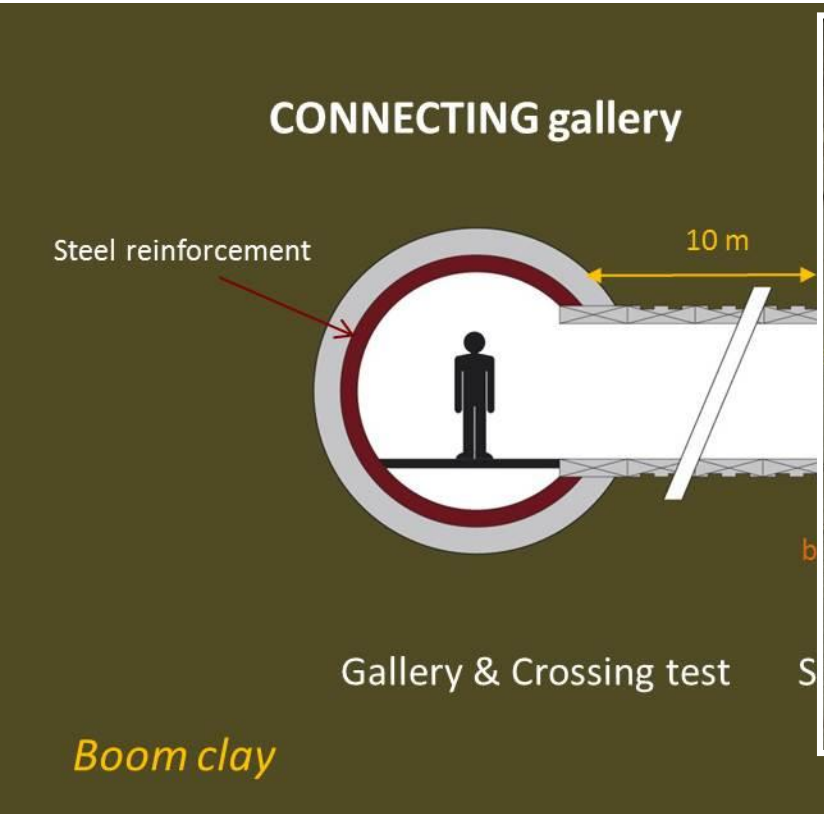
1. **Gallery & Crossing test**
2. **Seal test**
3. **Heater test**



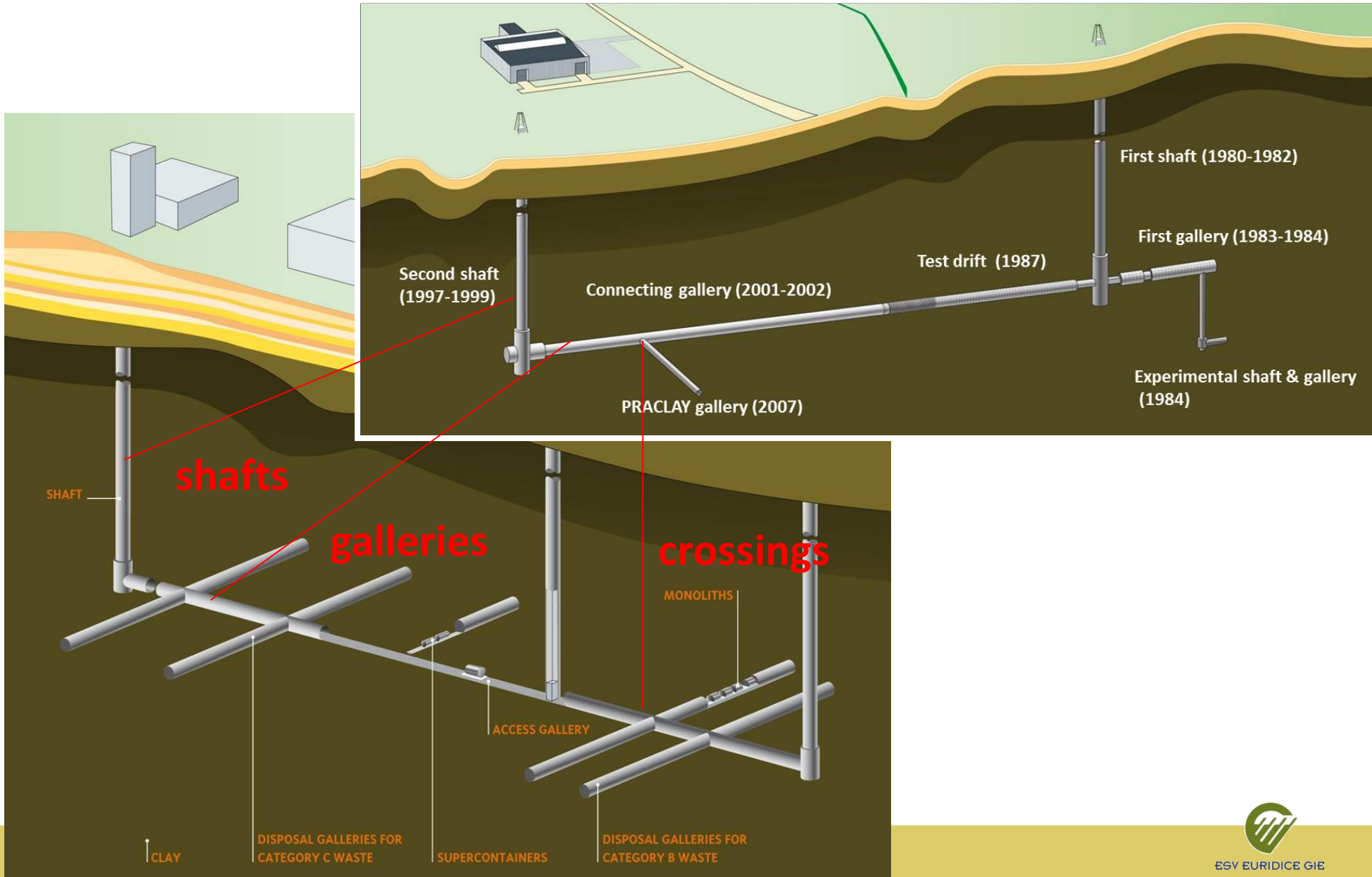


1. Gallery and Crossing test – main objectives

- Demonstrate the feasibility of a crossing between an access gallery and a disposal gallery
- Further characterise the hydromechanical behaviour of the Boom Clay



Feasibility of underground constructions

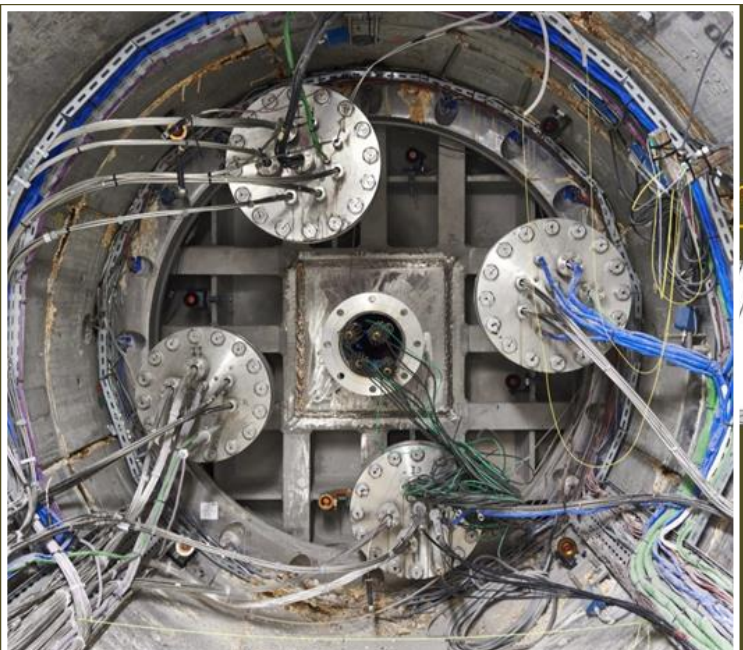


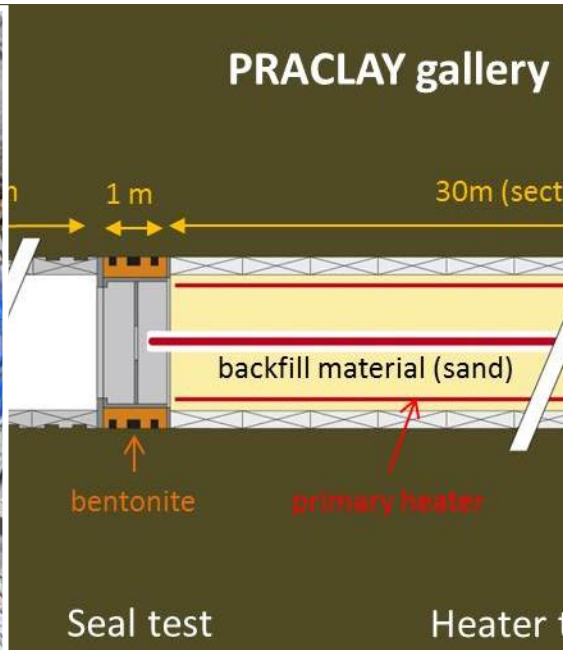
2. Seal-test – objectives

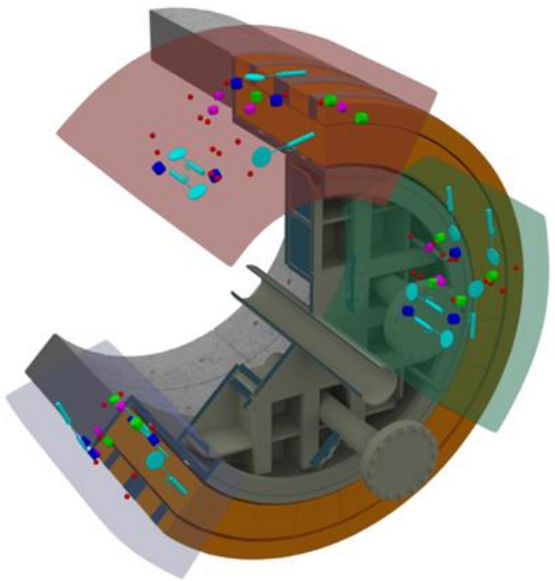
The main reason for installing the seal is to provide the hydraulic boundary conditions required for the Heater Test, by separating the heated section of the gallery and its surrounding excavation disturbed zone from the non-heated section.

SEAL = Steel cylinder, physically closing of the heated part of the gallery

+ Ring of bentonite between the steel cylinder and the Boom Clay to lower the hydraulic conductivity of the clay around the seal, to create quasi-impermeable boundary conditions at the intersection between the two parts







3. Heater test - objectives

•**To study the large-scale Thermo-Hydro-Mechanical response** of the Boom Clay to the excavation of a dipsosal gallery and to a large thermal load representative for high-level heat-emitting waste, more specific:

- Confirm the knowledge about the THM properties of the Boom Clay at large scale (from lab tests and smaller scale in situ test – ATLAS experiments)
- Evaluate other THM effects of the thermal load with a focus on the evolution of the EDZ and, in particular, its permeability

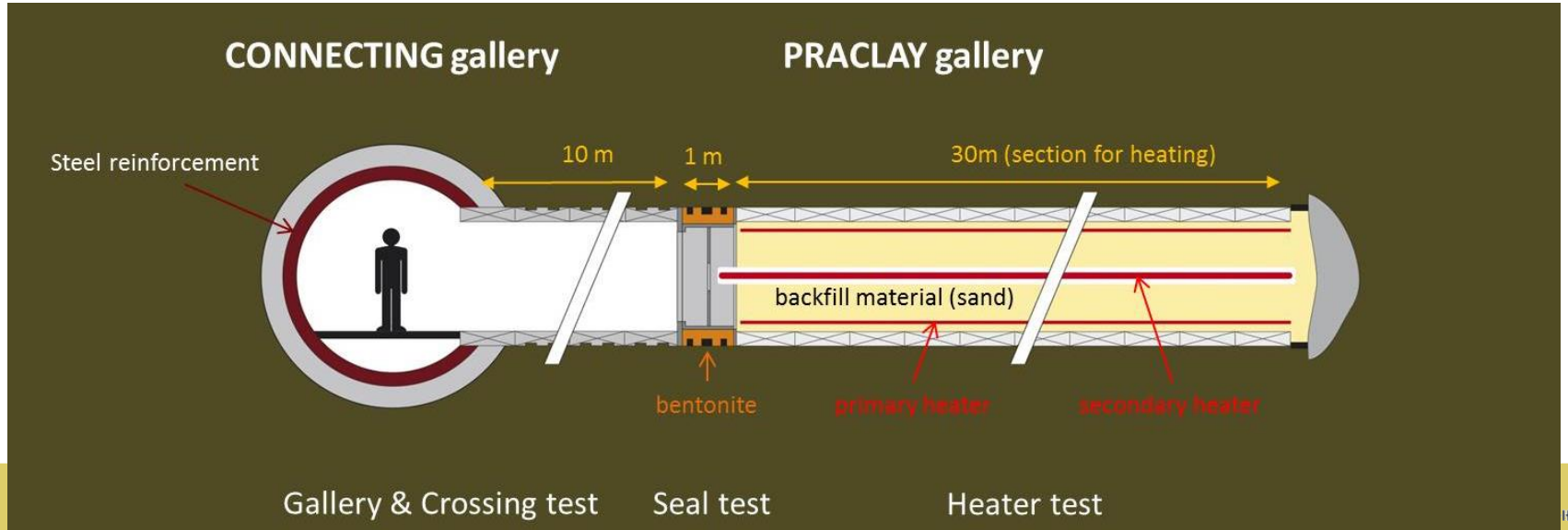
•**Assess the stability of the concrete lining** under thermal loading

•**Increase the knowledge of the performance and reliability of monitoring devices** under thermal stress and heat

PRACLAY Heater Test : design

The Heater test is designed to be performed under a reasonably conservative combination of thermal, hydraulic and mechanical conditions…

- Because it is not possible to fully reproduce the time scale, the spatial scale and the boundary conditions of a real repository
- To make sure that the test remains valid if the geological disposal design changes in future



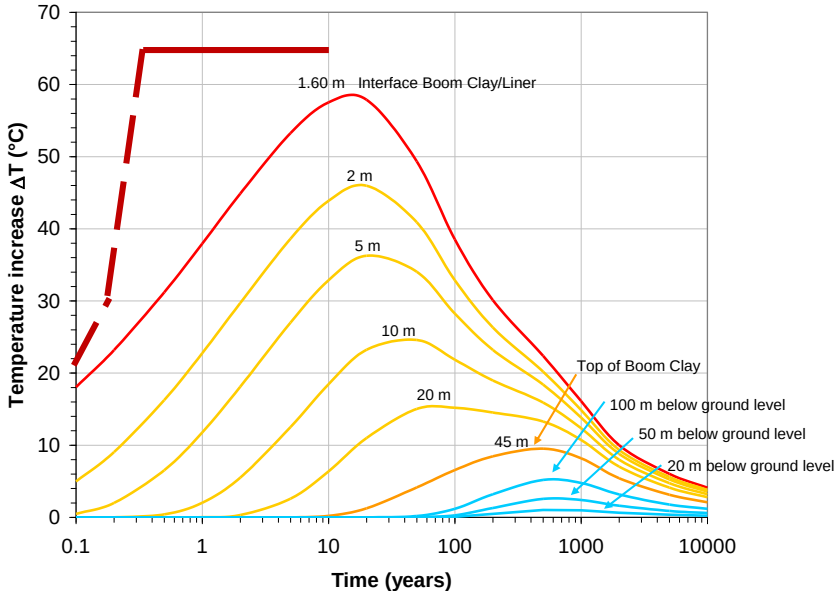
PRACLAY Heater Test : design

Thermal conditions :

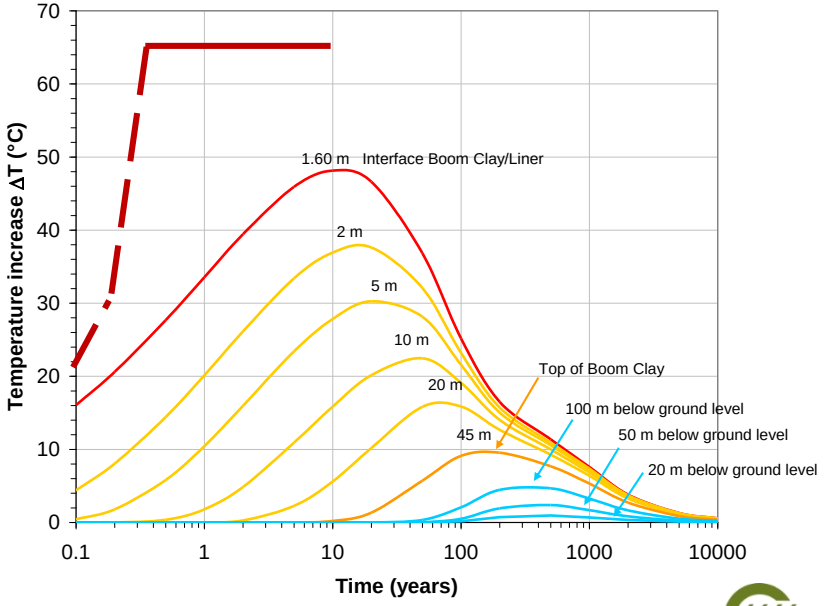
- Stepwise heating untill 80°C on the contact lining/Boom Clay
- Heating during 10 years (or more)

= Heating path of the PRACLAY Heater Test

spent fuel



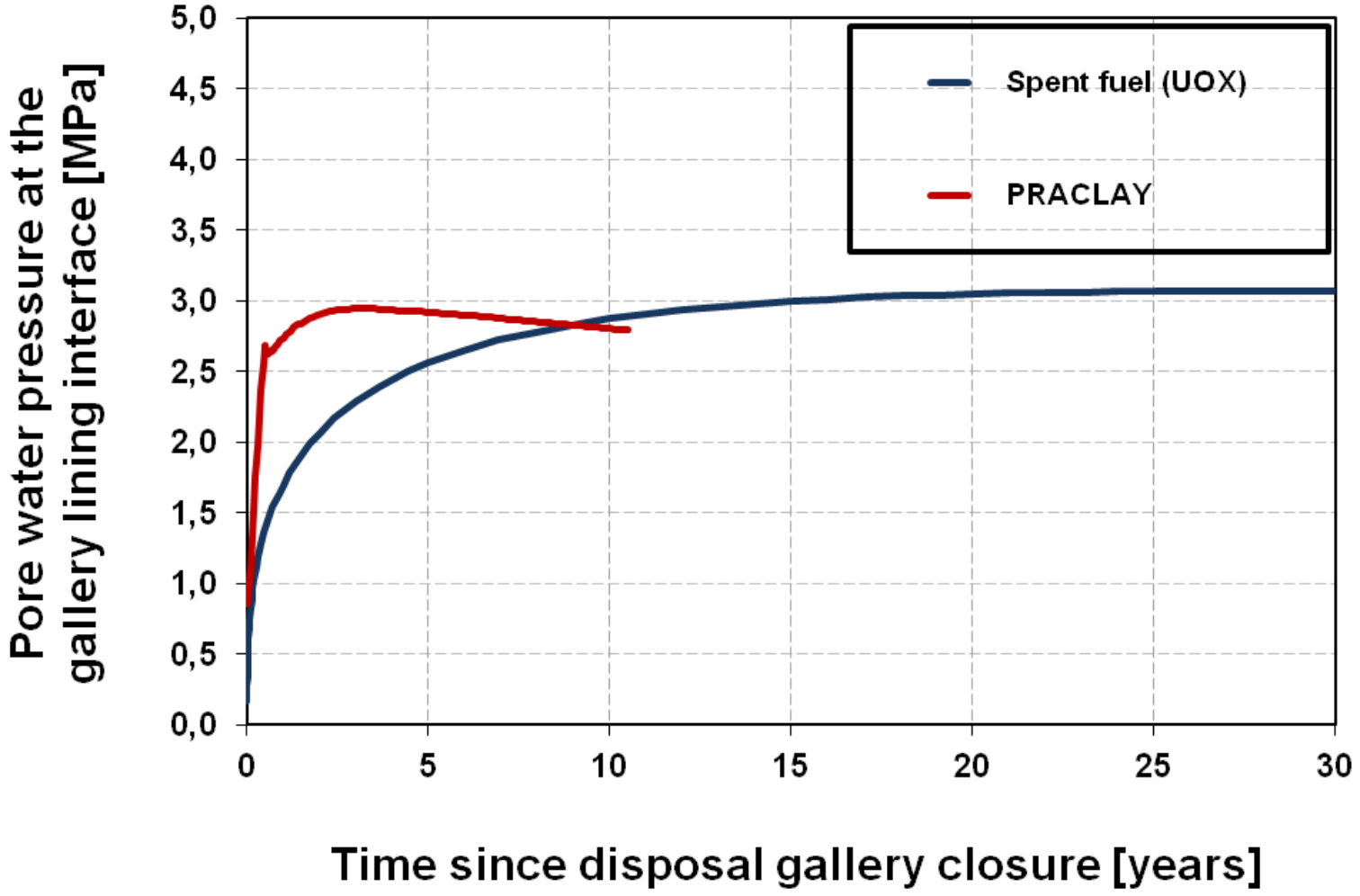
vitrified waste



Temperature evolution around a repository (SC design, O/N 2006)

PRACLAY Heater Test : design

Hydraulic conditions : as much undrained as possible (more penalising)



The “undrained” boundary condition will be realised by:

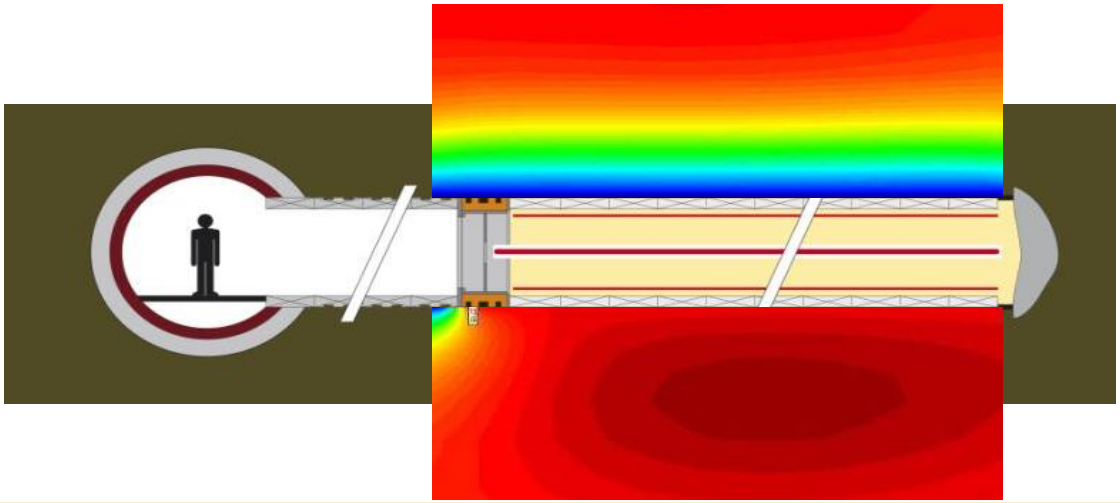
- Backfilling the heated part of the gallery with saturated high permeable material which allows to easily build-up the higher PWP as expected by the undrained boundary condition upon heating

Note: build a fully “impermeable” liner is not feasible/economical

- Installing an hydraulic seal at the intersection between the heated and the non-heated part of the gallery with bentonite

  ➔ create an “impermeable zone” to “close” the PRACLAY gallery (by swelling)

  ➔ maintain the PW at the heated section



Instrumentation programme

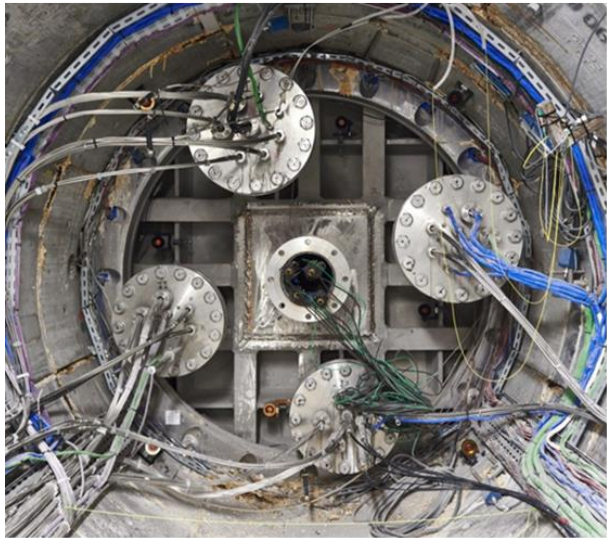
Temperature

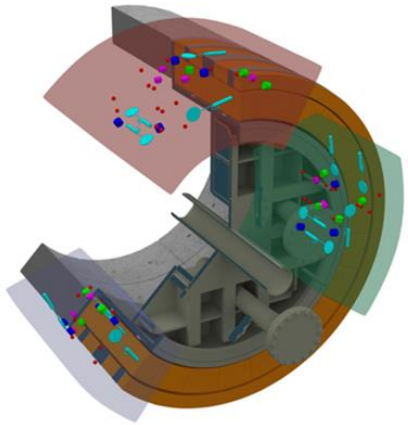
Total pressure

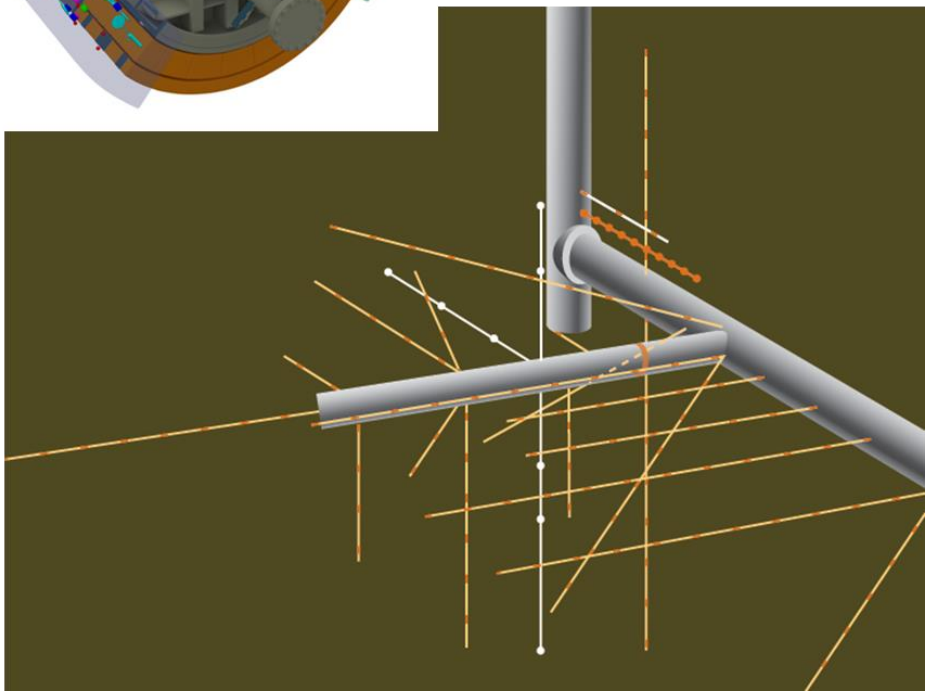
Pore water pressure

Strain

…

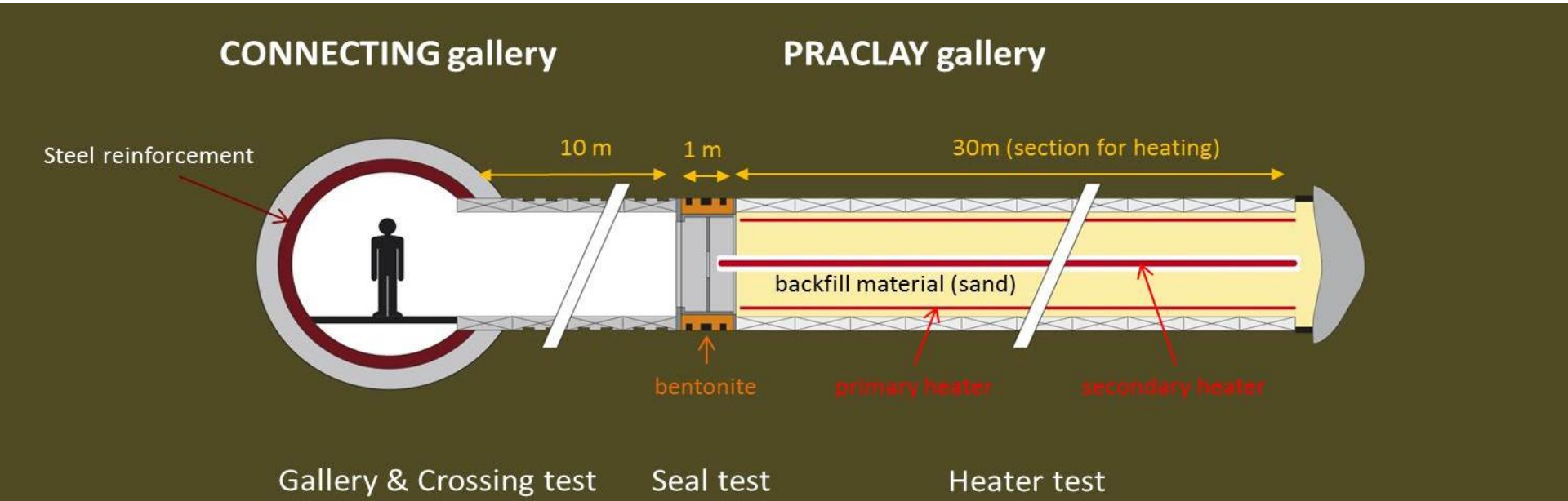




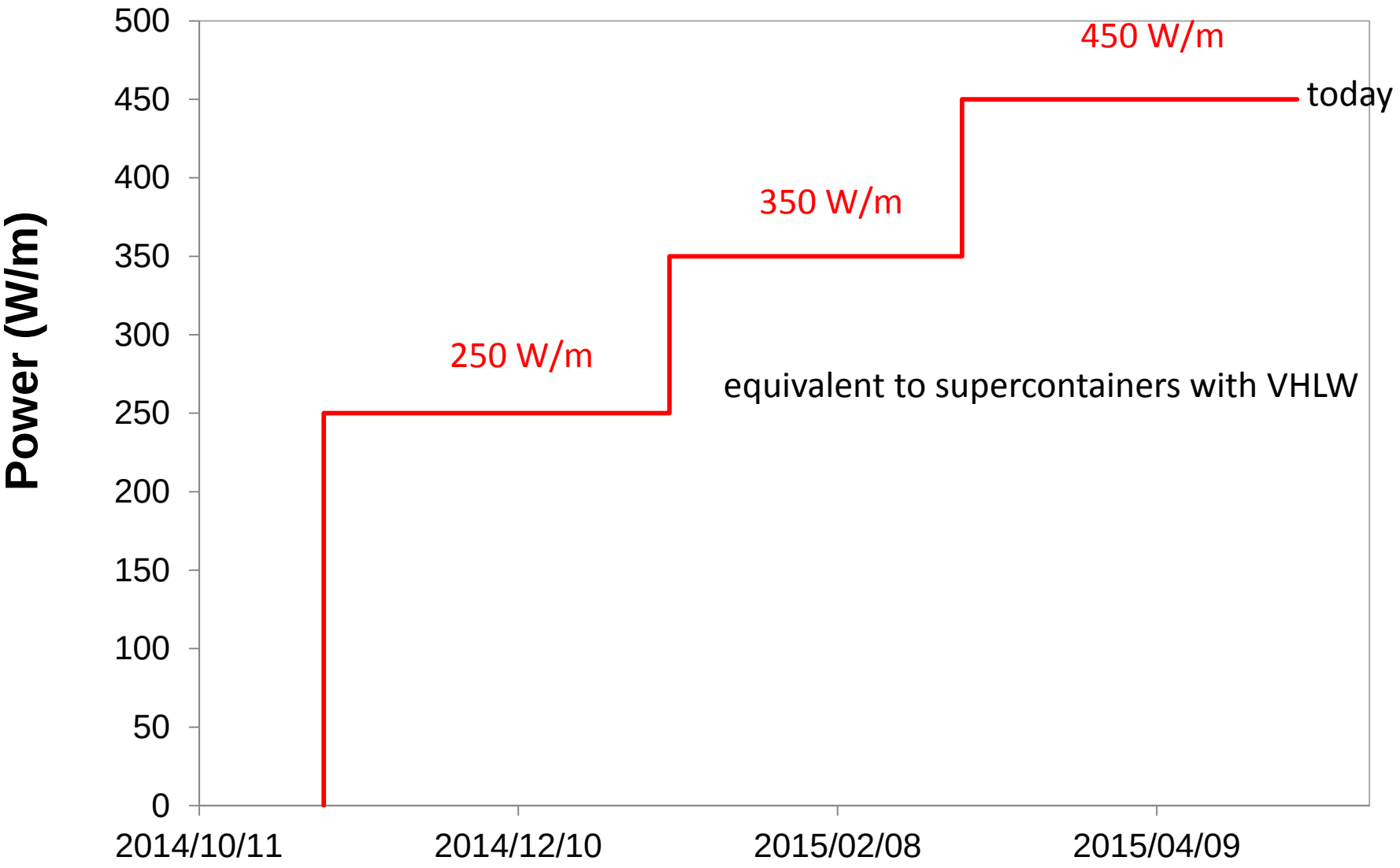


Timeline of the PRACLAY experiment

- Construction of the PRACLAY gallery: 2007
- Installation of the seal: 2010
- Installation of the primary heating system: 2010
- Backfilling of the gallery (sand), hydration of the gallery: 2011
- Installation of the secondary heating system (part 1): 2012
- Installation of the secondary heating system (part 2): 2014
- Hydration and swelling of the bentonite: 2010-2014
- Heating: 2014/2015 - 2024/2025
- Dismantling of the gallery, investigation of the gallery lining stability: 2025

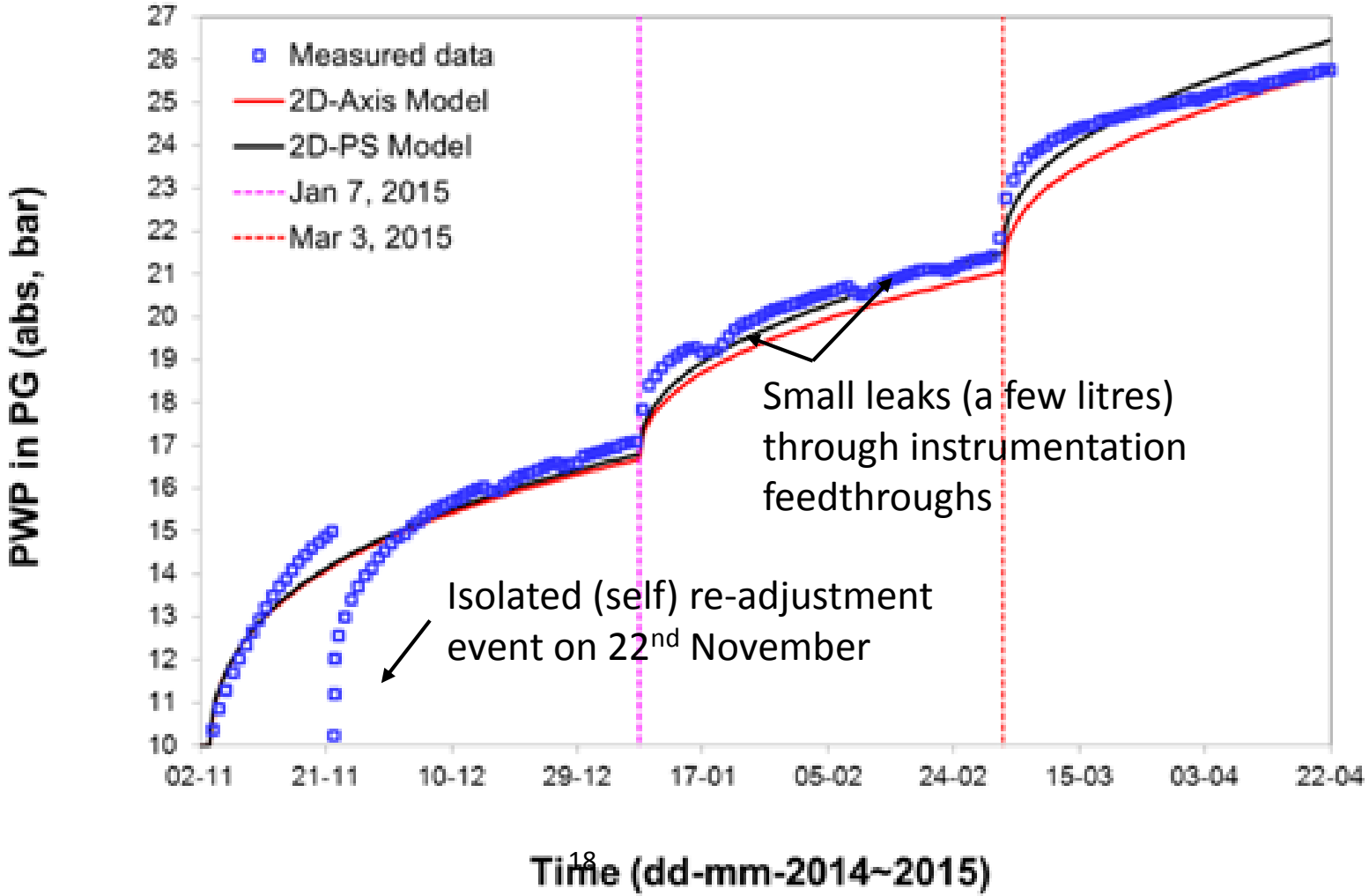


Status of the PRACLAY Heater test

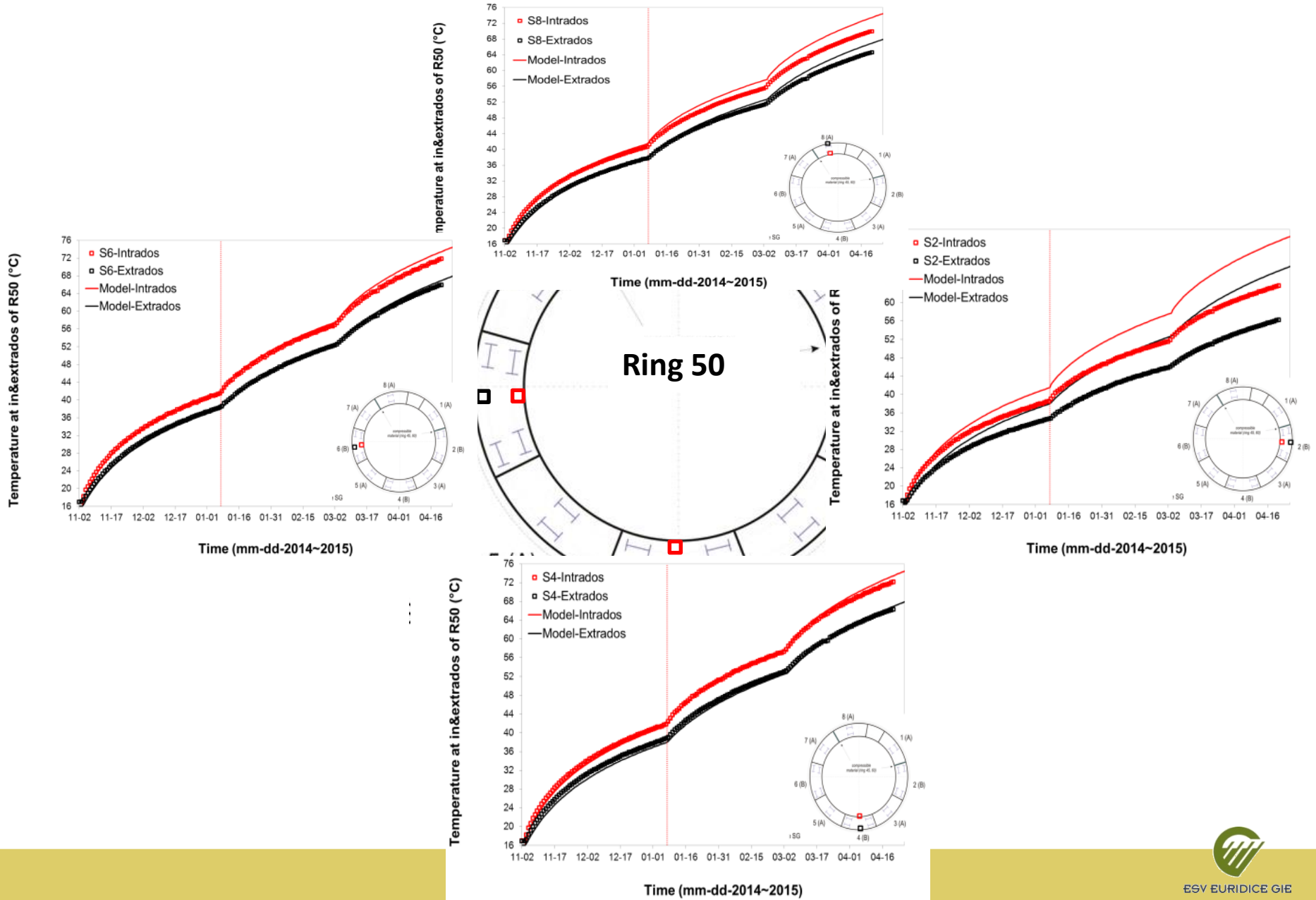


What about the pressure in the gallery ?

- Gallery pressurization is a test control parameter
- Has been left to evolve freely since start of heating

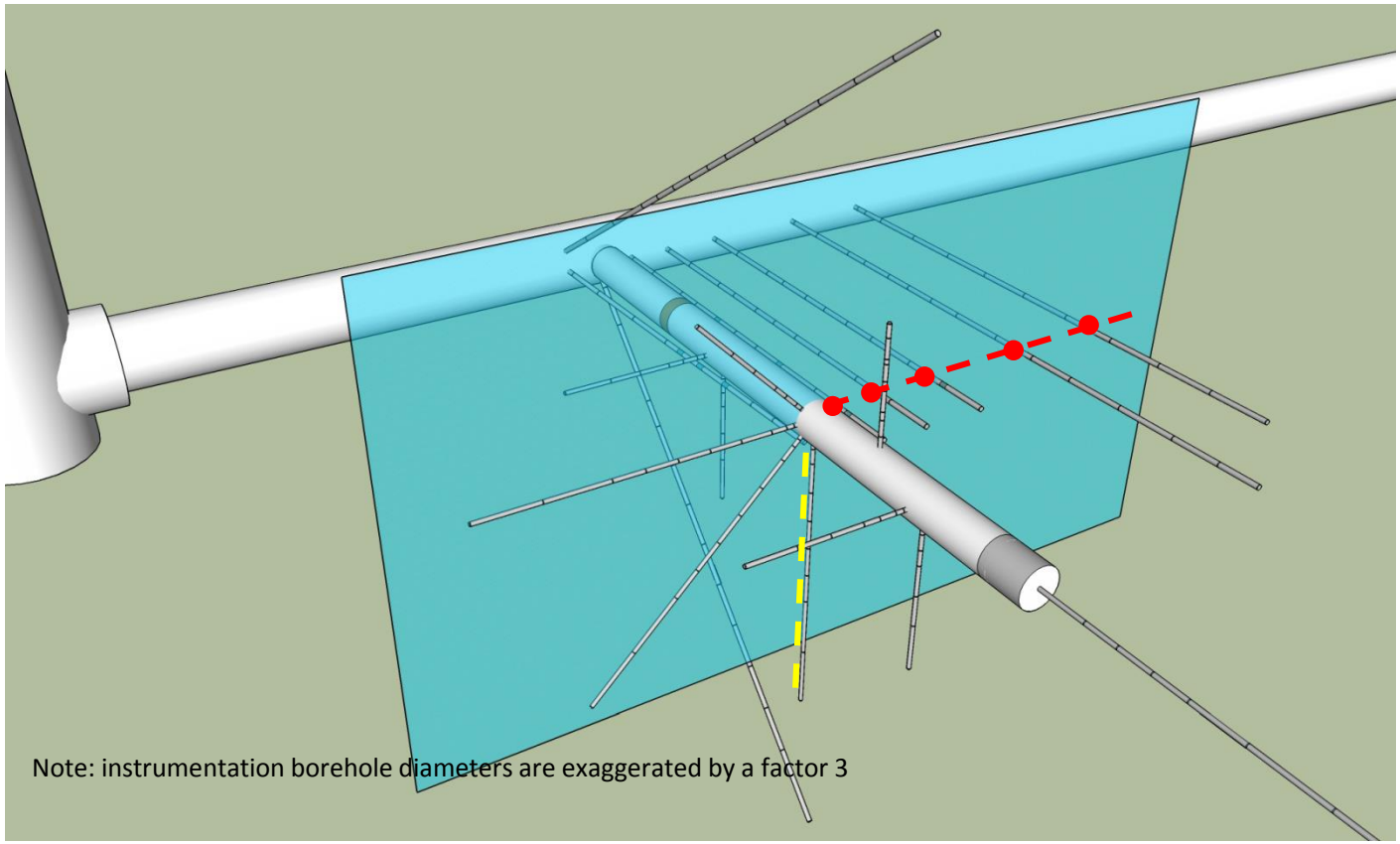


What about the Temperature in the gallery linning ?



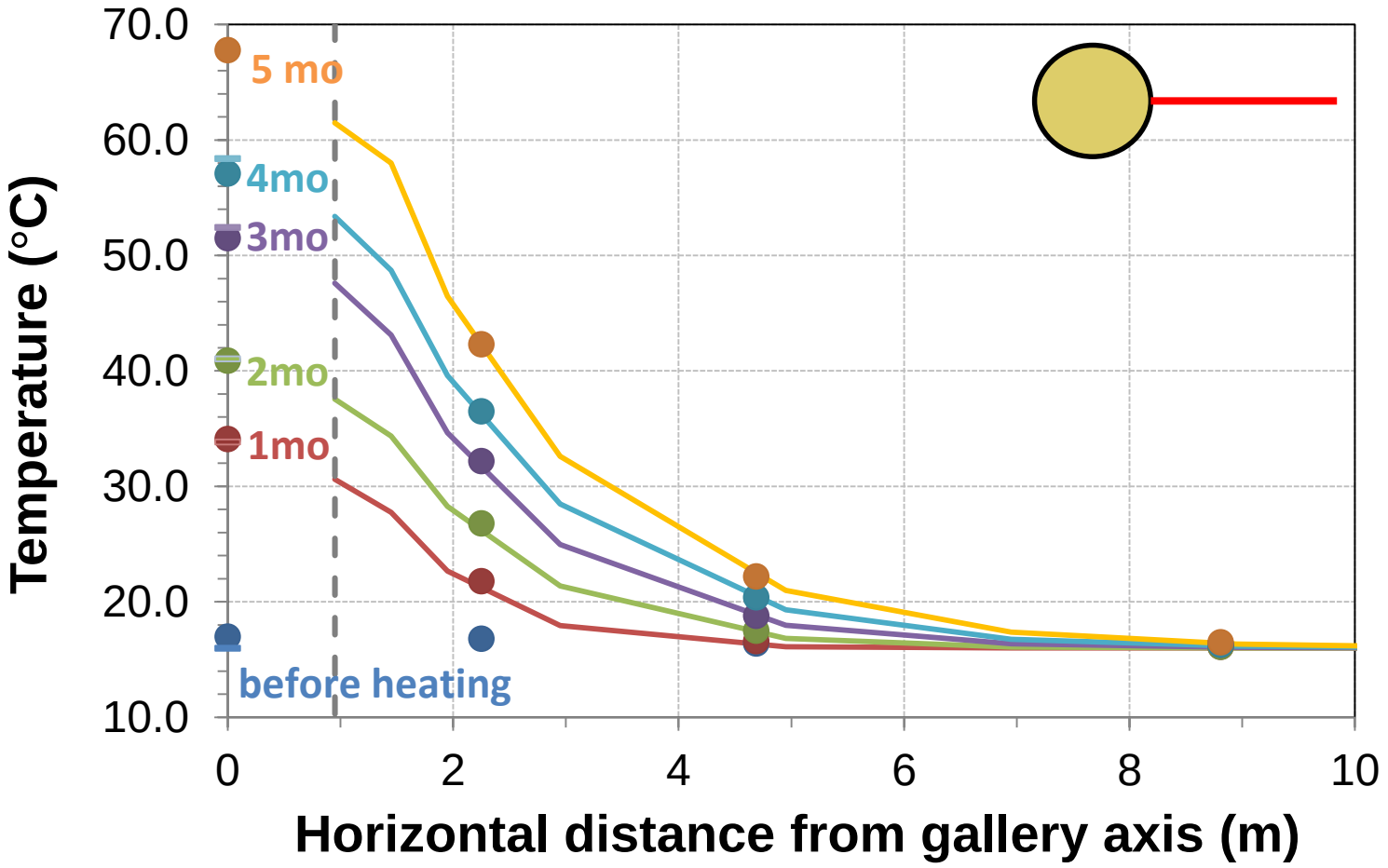
what about temperatures in BC ?

- Horizontal and Vertical radial T profiles in the mid-plane of PRACLAY Heater test



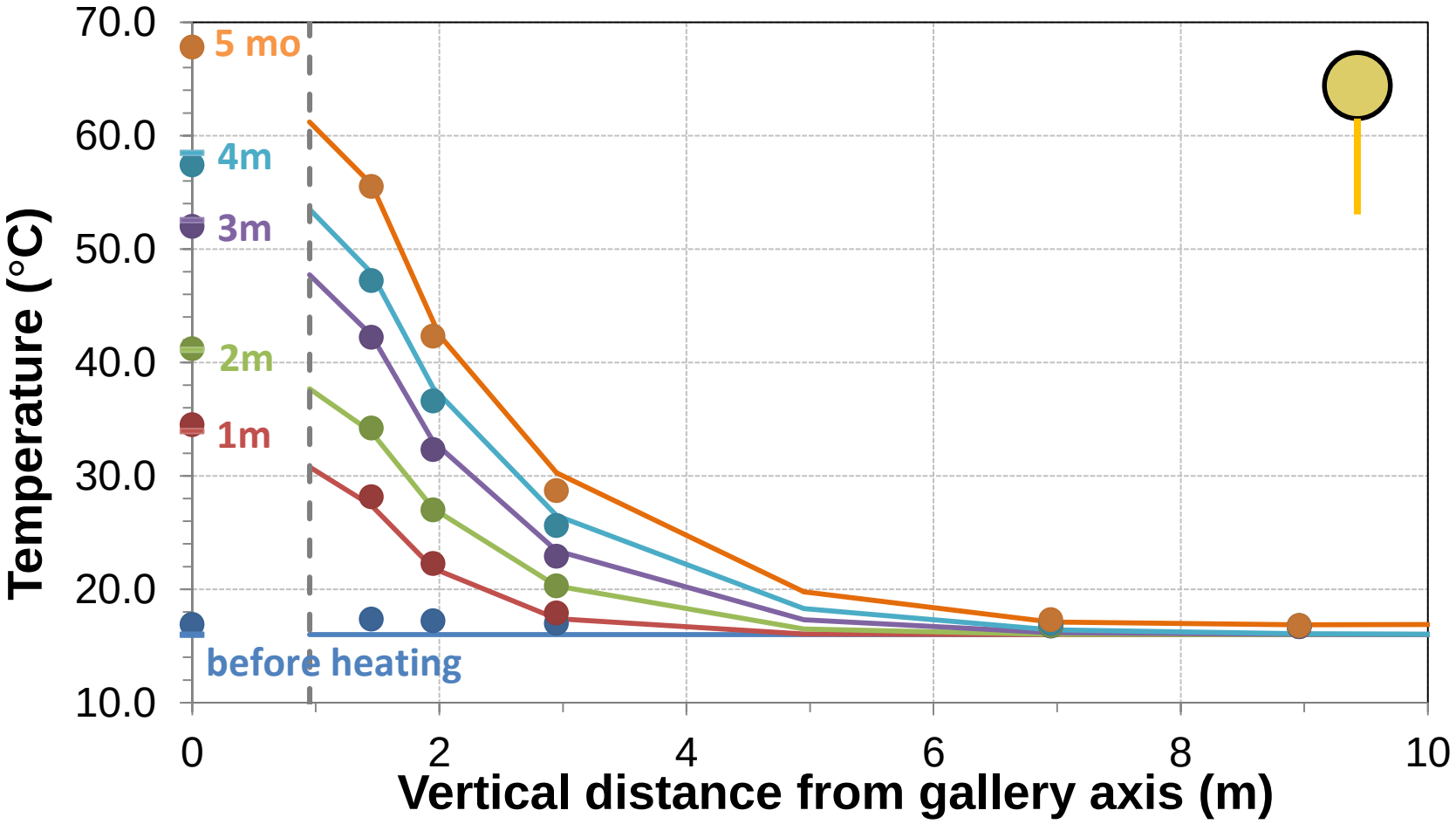
Horizontal temperature profile evolution

- Modelling (solid line) vs. actual data (markers):



Vertical temperature profile evolution

Modelling (solid line) vs. actual data (markers):



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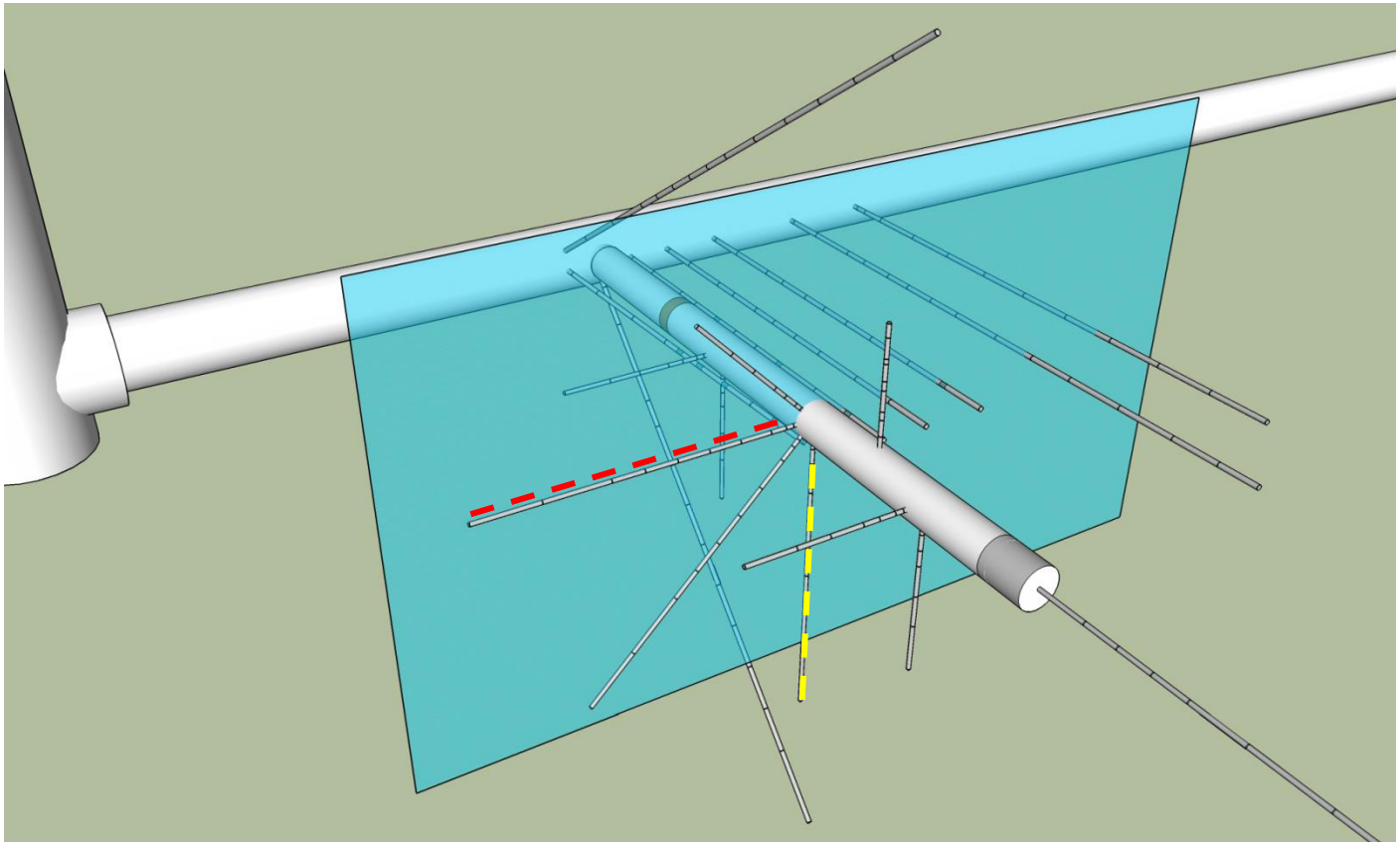
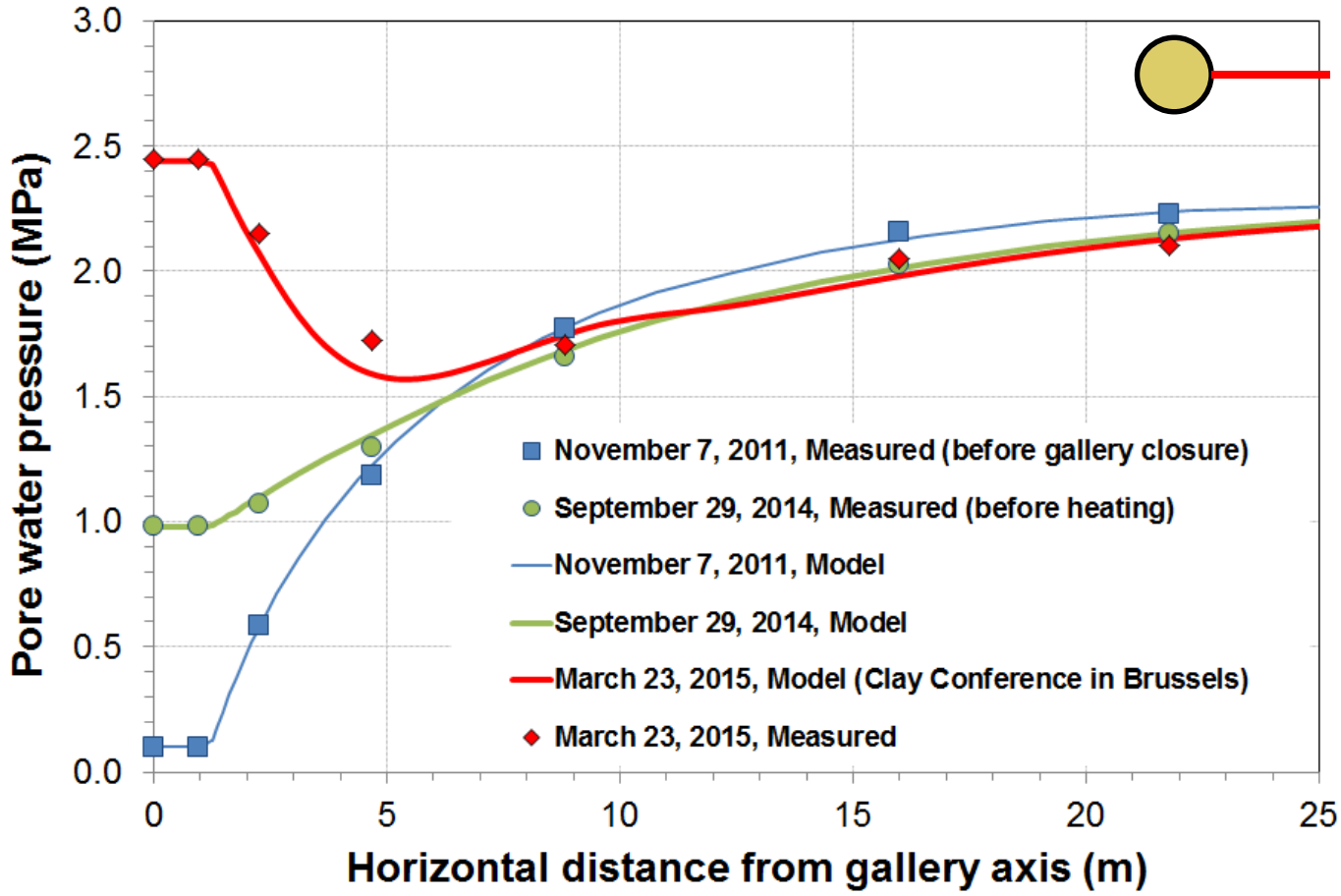
what about pore water pressure in BC ?

- Horizontal and vertical radial PWP profiles in the mid-plane of PRACLAY Heater test



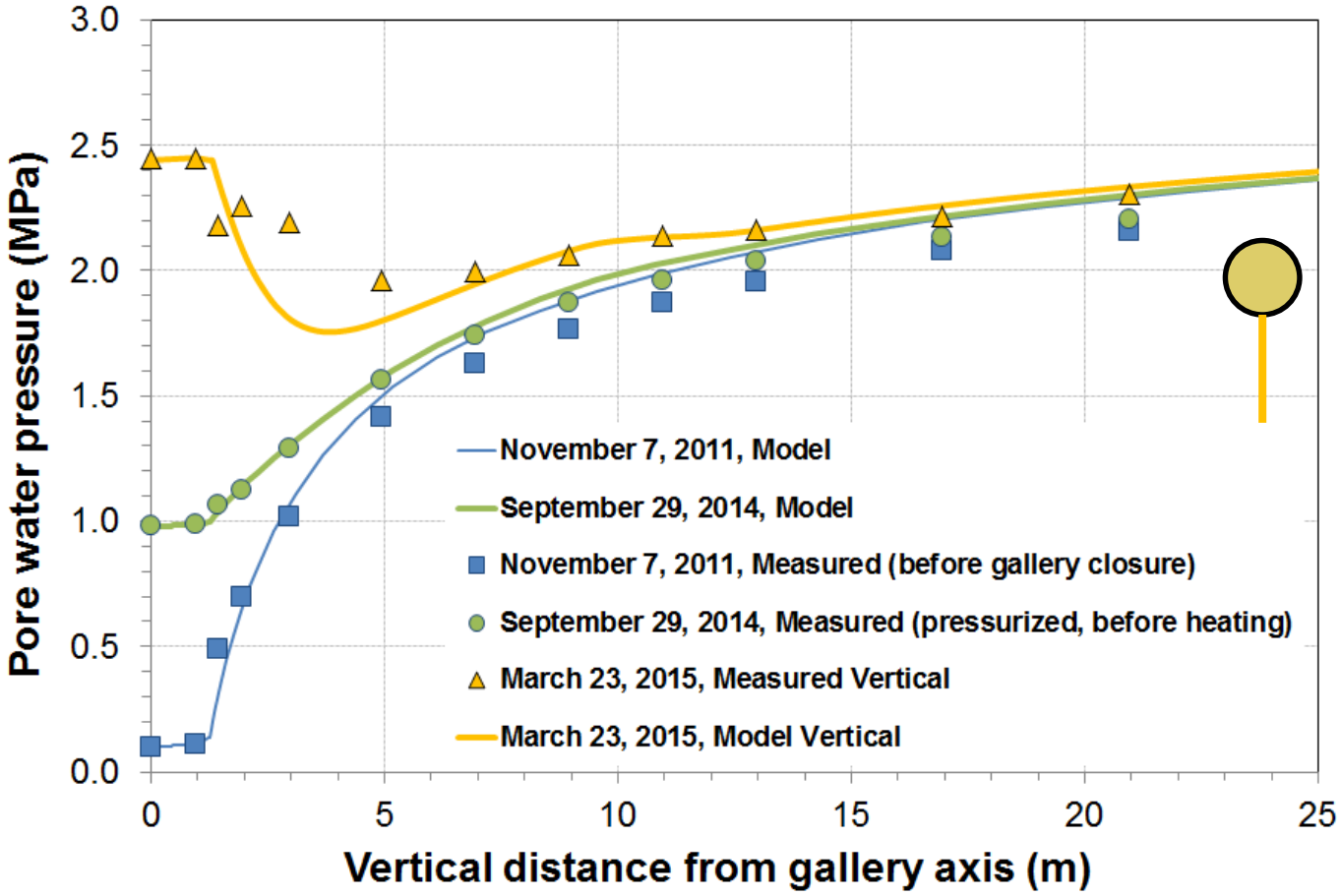
Horizontal radial pore pressure profile

Modelling (solid line) vs. actual data (markers):



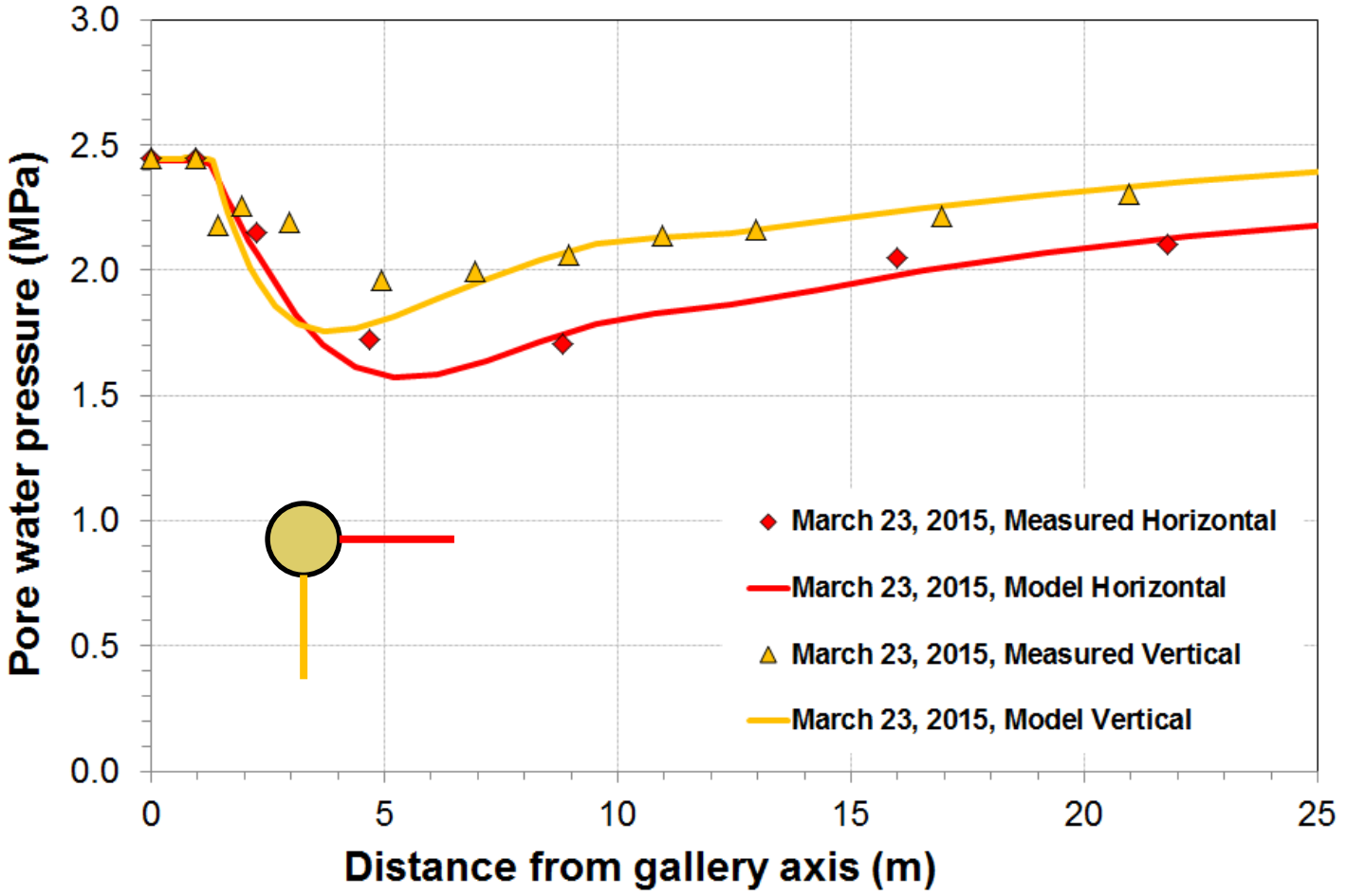
Vertical radial pore pressure profile

Modelling (solid line) vs. actual data (markers):



Horizontal vs. vertical PWP profiles

- Differences between observed vert. & hor. profiles
- Was expected (HM anisotropy!), but underestimated



Provisional conclusions

6 months after switch-on, experimental setup and Boom Clay are generally behaving as expected

- Temperature evolution in line with expectations
- Pore water pressures evolution trends are consistent
- Model might underestimate anisotropy effects

=> **Still a long way to go !**

- When 80°C target is reached, power will then be adjusted to keep that temperature for 10 years
- More than 1000 sensors in Boom Clay, gallery and seal
  - Lining stresses, seal swelling, pore water chemistry…
- Continual improvement of process understanding

Thank you for your attention !

Acknowledgements

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- Others…