DOPAS Training workshop 2015

Learning Unit 3 : Design of a seal for an experiment/demonstrator within the broader context of RD&D programmes

Safety assessment and performance assessment of closure as design input

How to move from initial design in an iterative manner to the final experiment design and construction (to as build) and assess the outcome

Andra's scientific programme and the main questions to be replied for the next report (DAC) and after submission of DAC

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D3 3.1.1 16 September 2015

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Summary

Introduction and context

Actual seal concept

The main scientific questions

The main technological challenges
- TRL scale

The main experiences/demonstrators in the actual program

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Introduction and Context

The 1991 Waste Act

- Creation of « Andra » as a public independant body
- 3 research areas for High Level Long-lived Waste: P/T; long term storage; geologic disposal

1996: Licence application for 3 URLs (clay; granite)

1998: Government decision to licence the Meuse/Haute-Marne URL licence,

1ST SA → 2001: Intermediate Clay report, first NEA peer review…

2nd SA → 2005: Feasibility /safety assessment of safe geological disposal in Meuse/Haute-Marne clay layer, reviewed 2005-2006

The 2006 Programme Act: Reduce/avoid the burden on future generations

- Reduce volume and harmfulness of wastes
- Reference option for final waste that can no longer be treated: geological repository with respect to reversibility (100 y at least)
- Continue research on P/T (CEA) and interim storage (Andra) on a complementary basis.

3rd SA → 2009: Safety, reversibility and design options, reviewed 2010

2010-2012: Launch of the industrial design phase

2013: Public debate

4th SA → *2015-17: DOS (Safety Options) and Licence application*

Actual loop

Around 2018-2019: Law defining reversibility conditions

2025: Operation

The actual seal concept: reference

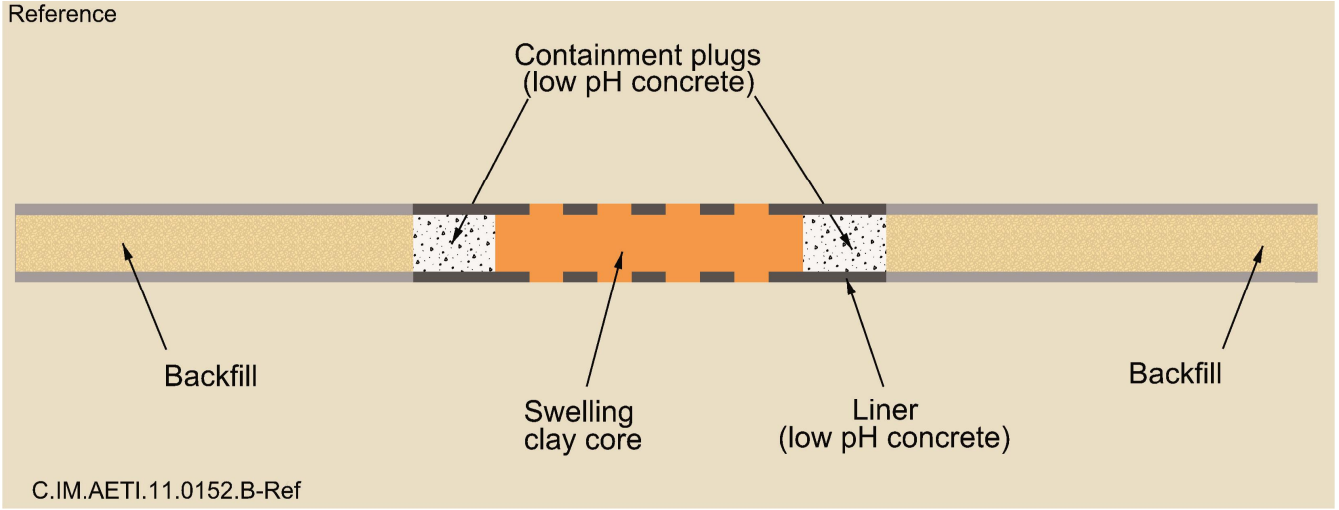
Multi-component system :

Bentonite core

- Low permeability
- Recompression of the EDZ (lower its permeability)

Partial removal of the concrete liner to ensure a good bentonite/EDZ interface

Concrete containment plugs to ensure mechanical stability of the bentonite core

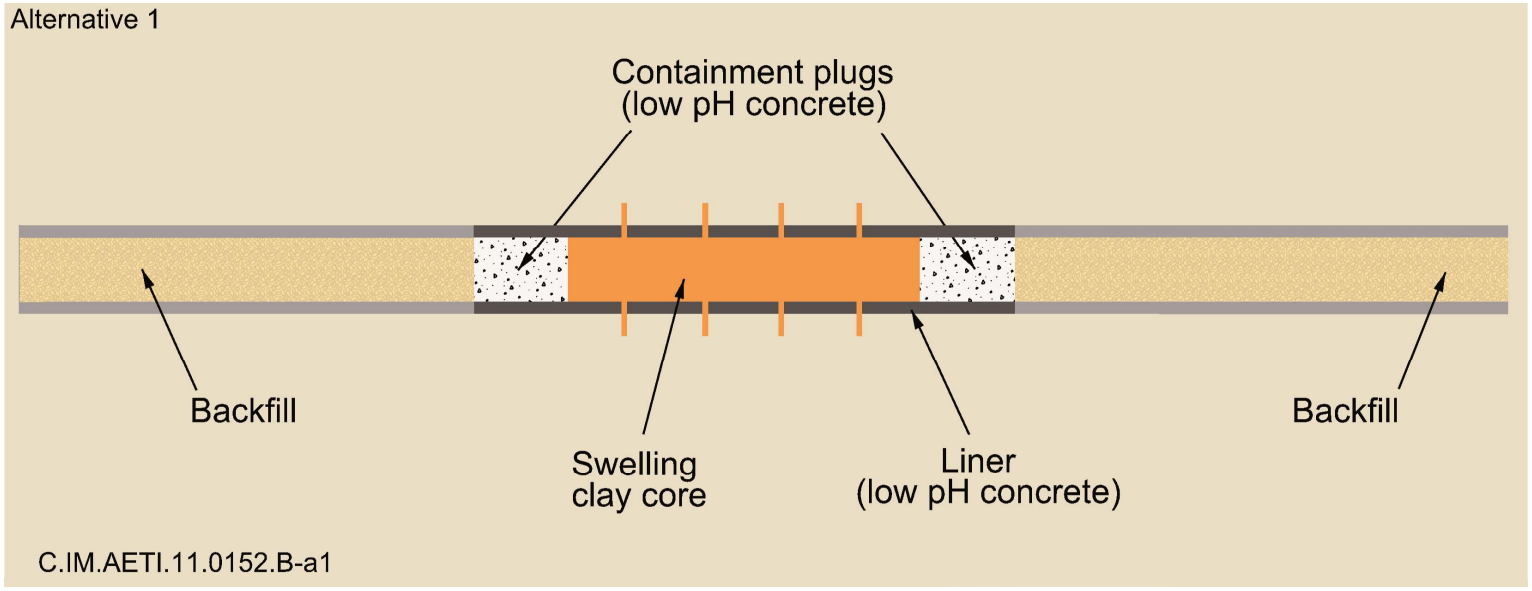


The actual seal concept: alternative

For the moment there is still significant uncertainties on the possibility to reduce the EDZ permeability by recompression through the swelling of the bentonite core.

Thus an alternative concept for the seal is studied, including hydraulic cuts of the EDZ

These cuts are filled with bentonite



The main scientific questions

Long term evolution of the (low pH) concrete

- Ø Chemical evolution in contact with clay (bentonite/argilites)
- Ø Effect of corrosion of the metal reinforcement in concrete components

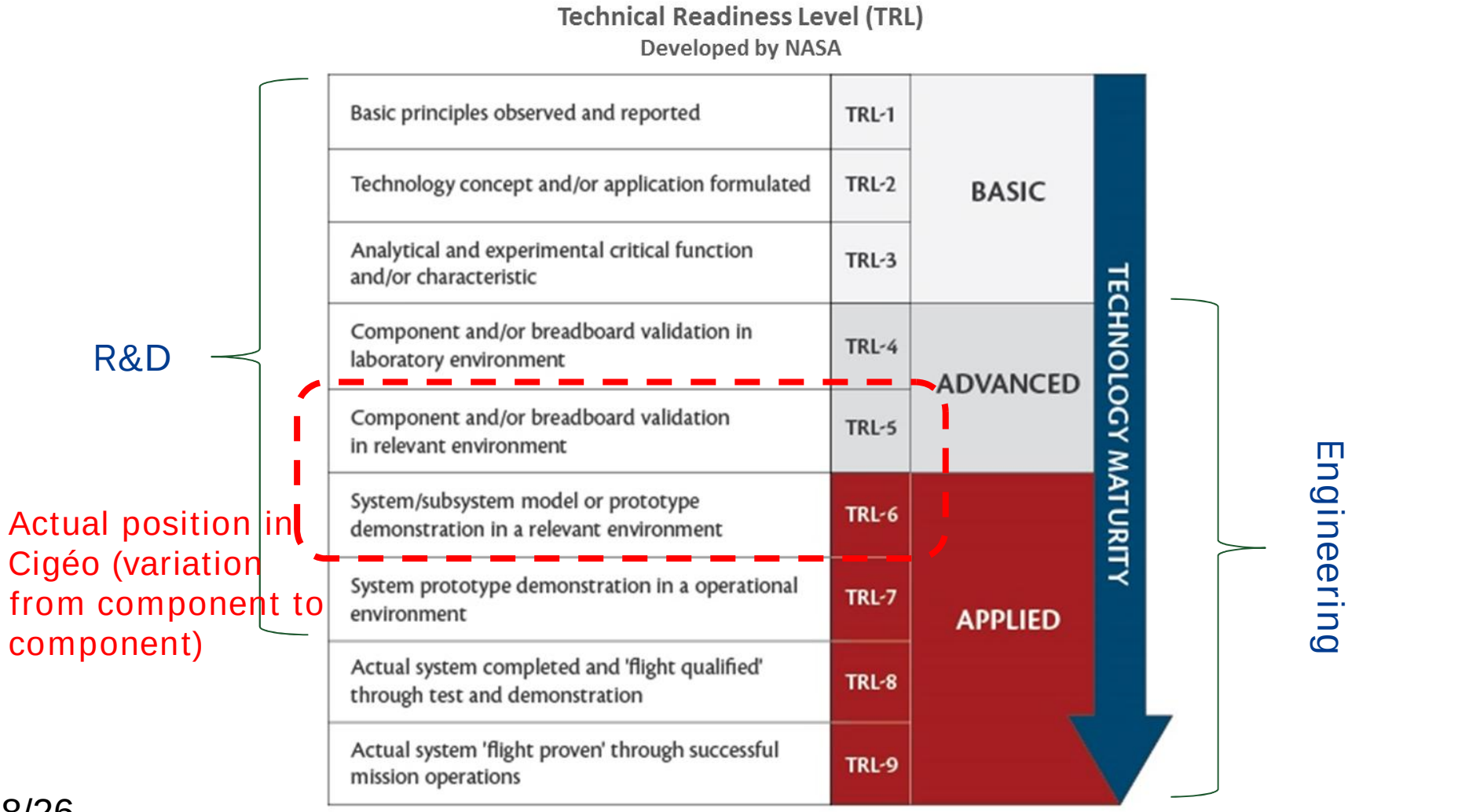
Long term evolution of the EDZ HM characteristics

- Ø Gas effects near resaturation
- Ø Mechanical behavior after recompression by the swelling of the bentonite core
- Ø Mechanical behavior after mechanical rupture of the concrete lining

Rehydration of the bentonite plug

- Ø Order of magnitude of the resaturation time
- Ø Effect of gas on the resaturation

Main Technological Challenges: the TRL scale



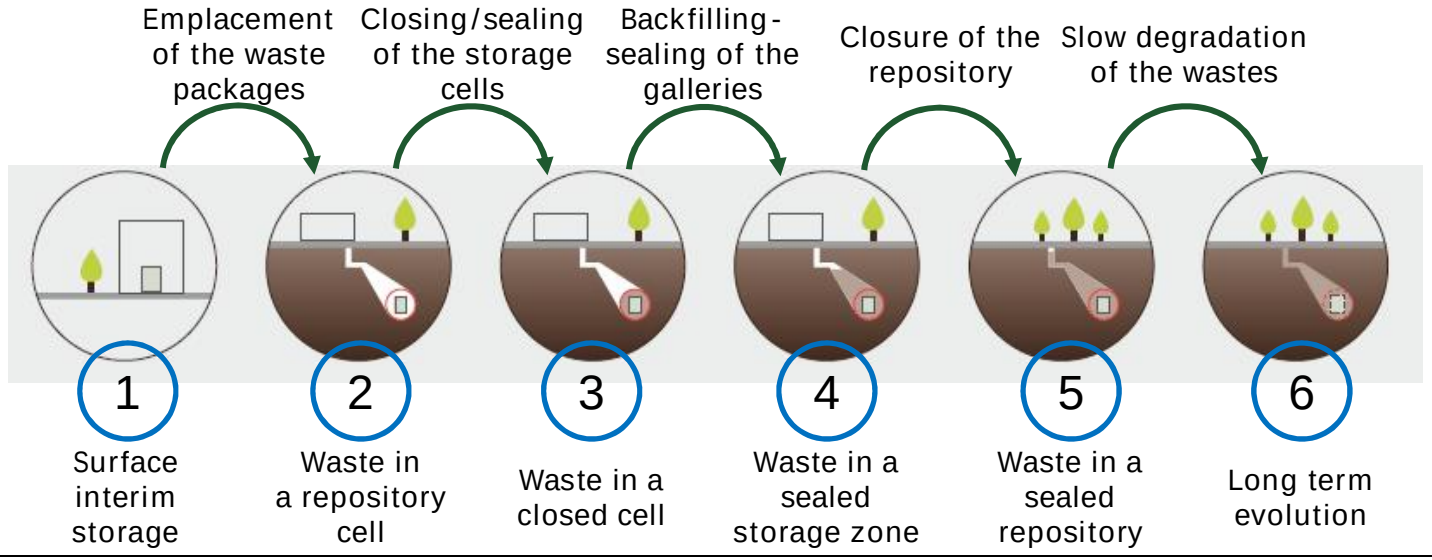
Main Technological Challenges: Retrievability

Why

- Ø To retrieve waste packages
- Ø Abilility to reverse the decisions taken today

How

- Ø Machines, packages, cells designed to allow the withdrawal of the waste packages
- Ø Progressive and changeable closing schedule to leave the choice to next generations
- Ø Appointments every 10 years with civil society to prepare the decisions



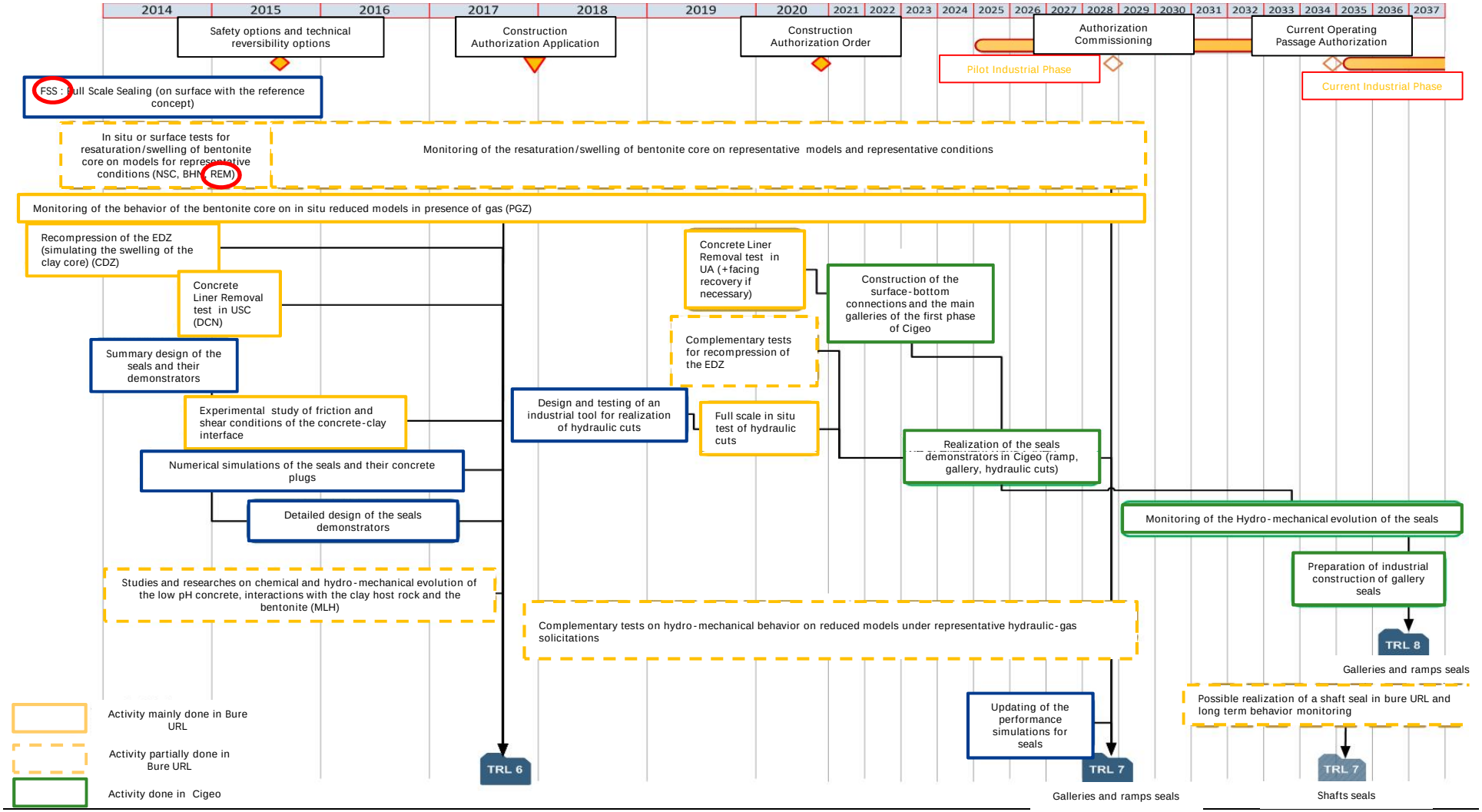
Main demonstrators in the actual program

Having a full spatial scale seal (10 m Ø, 60 m long) demonstrator with measurement during the whole resaturation time (several 1 000 years at least) and in a representative environment (URL) is impossible.

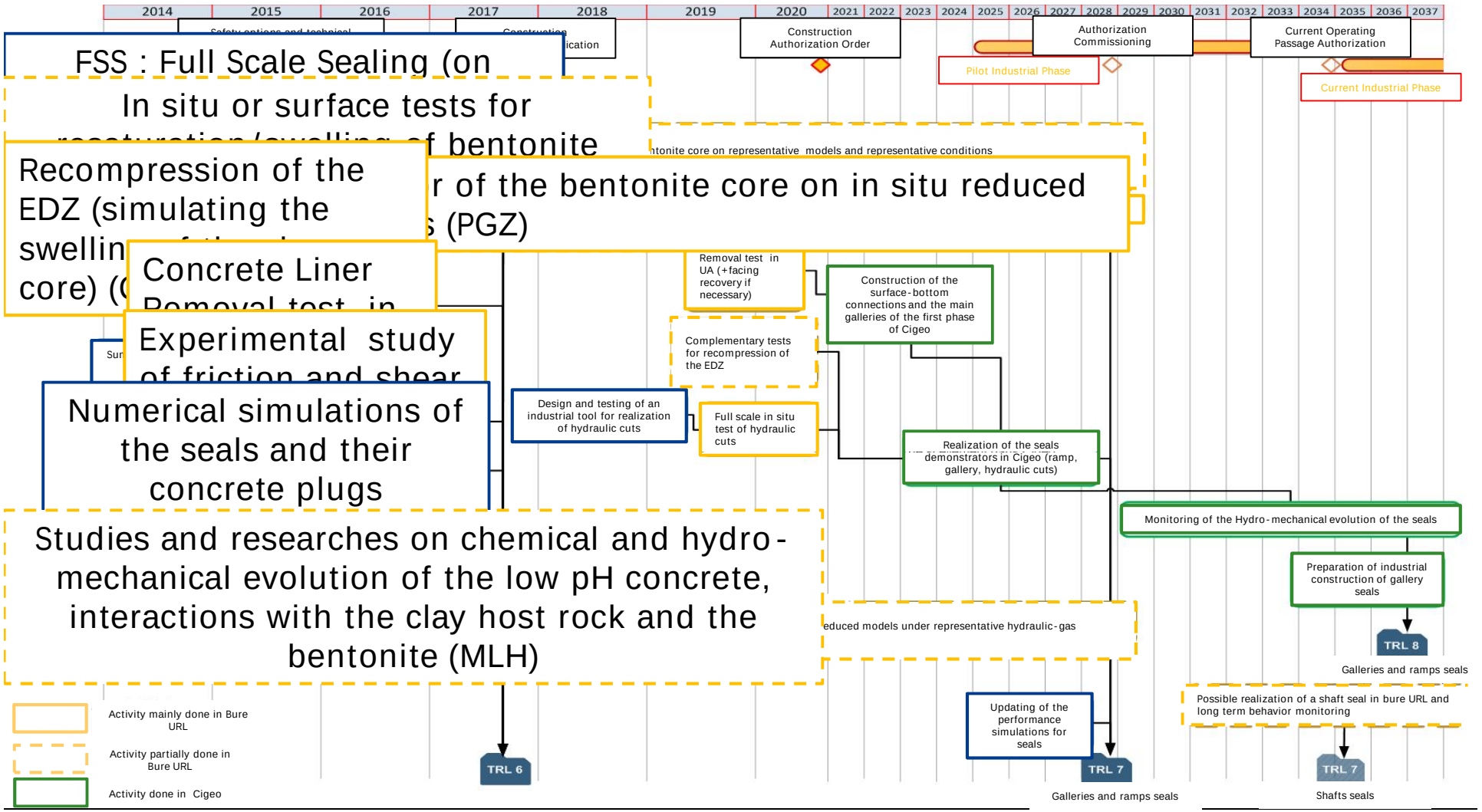
Andra has chosen to develop several complementary demonstrators covering the whole problematic by parts

They are all part of the RD&D program and are completed by a numerical simulations program

Introduction and Context
The actual RD&D development plan for seals (1)



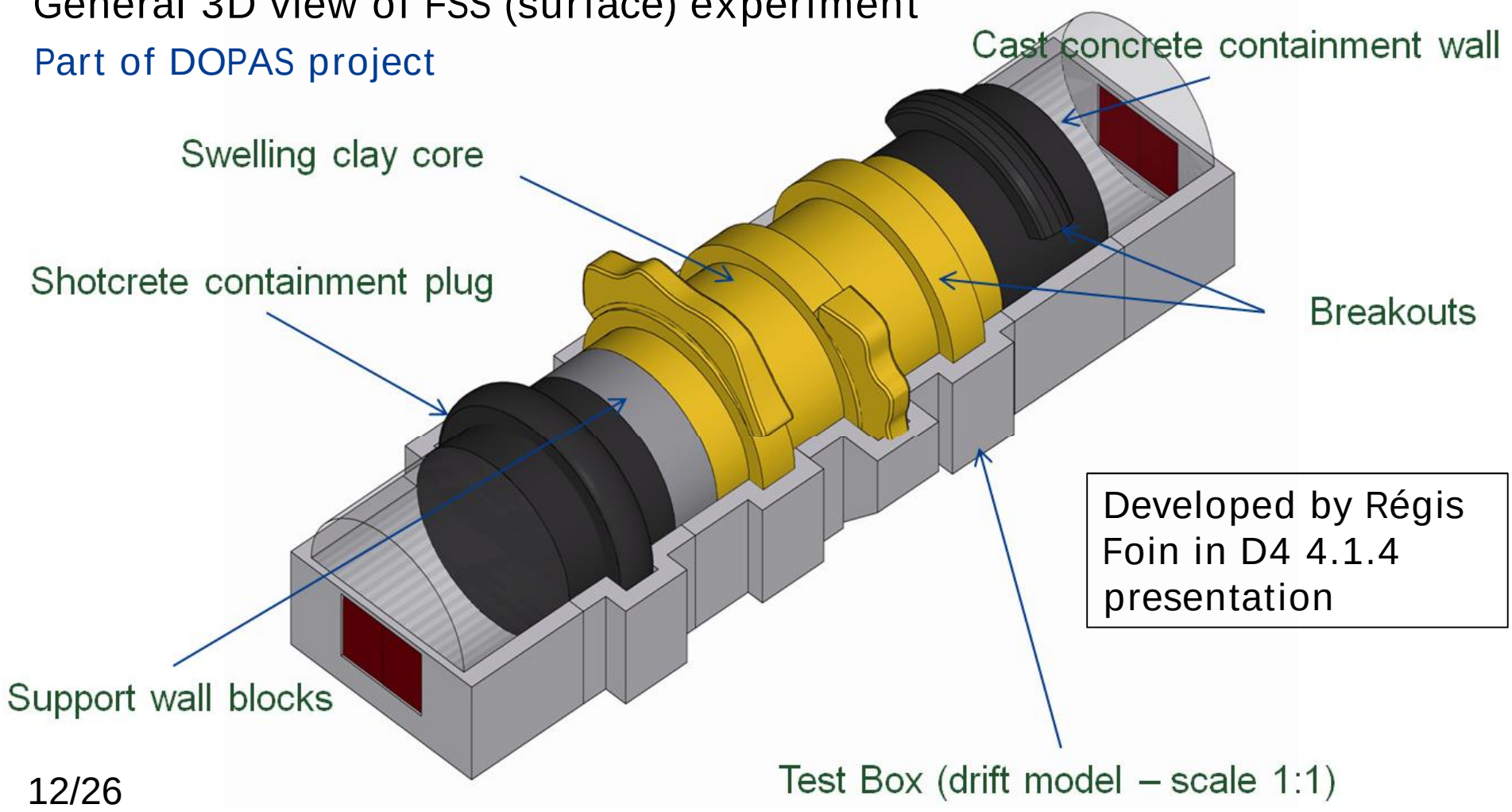
Introduction and Context
The actual RD&D development plan for seals (2)



Main demonstrators in the actual program

General 3D view of FSS (surface) experiment

Part of DOPAS project



Developed by Régis Foin in D4 4.1.4 presentation

Main demonstrators in the actual program

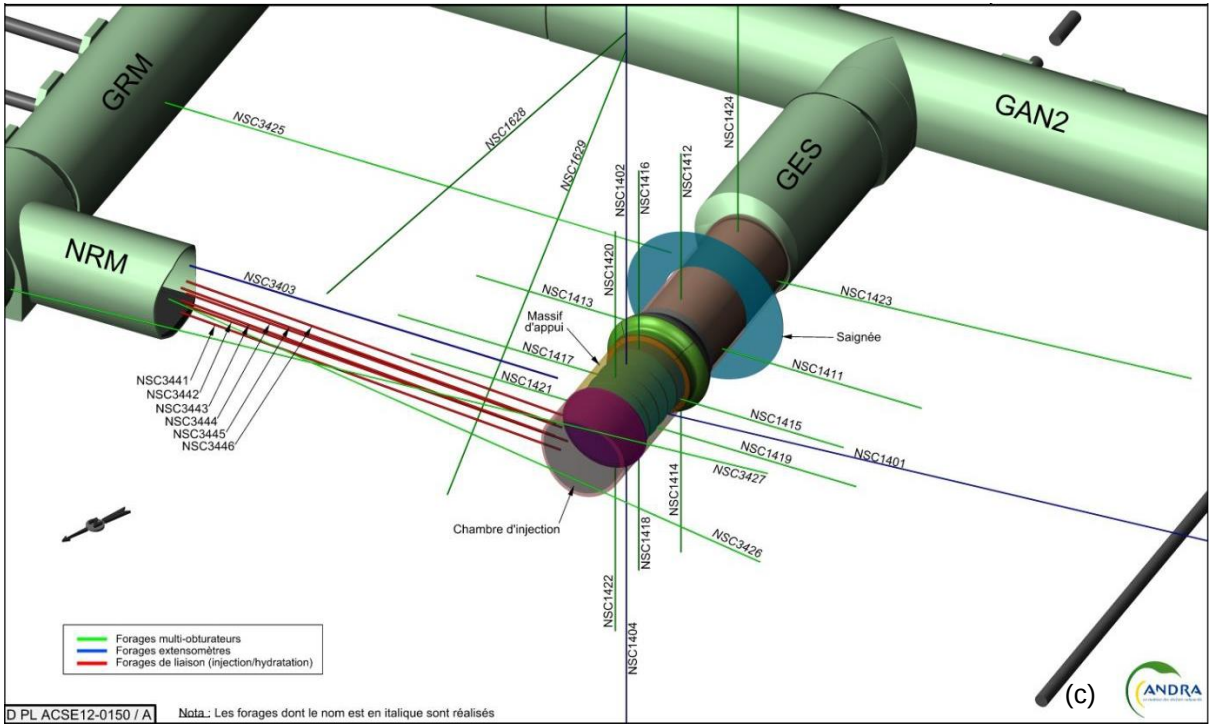
REM (surface) experiment, part of DOPAS Project : metric scale FSS bentonite mixture resaturation

Developed by Jacques Wendling on the D3 3.2.1 presentation

Main demonstrators in the actual program

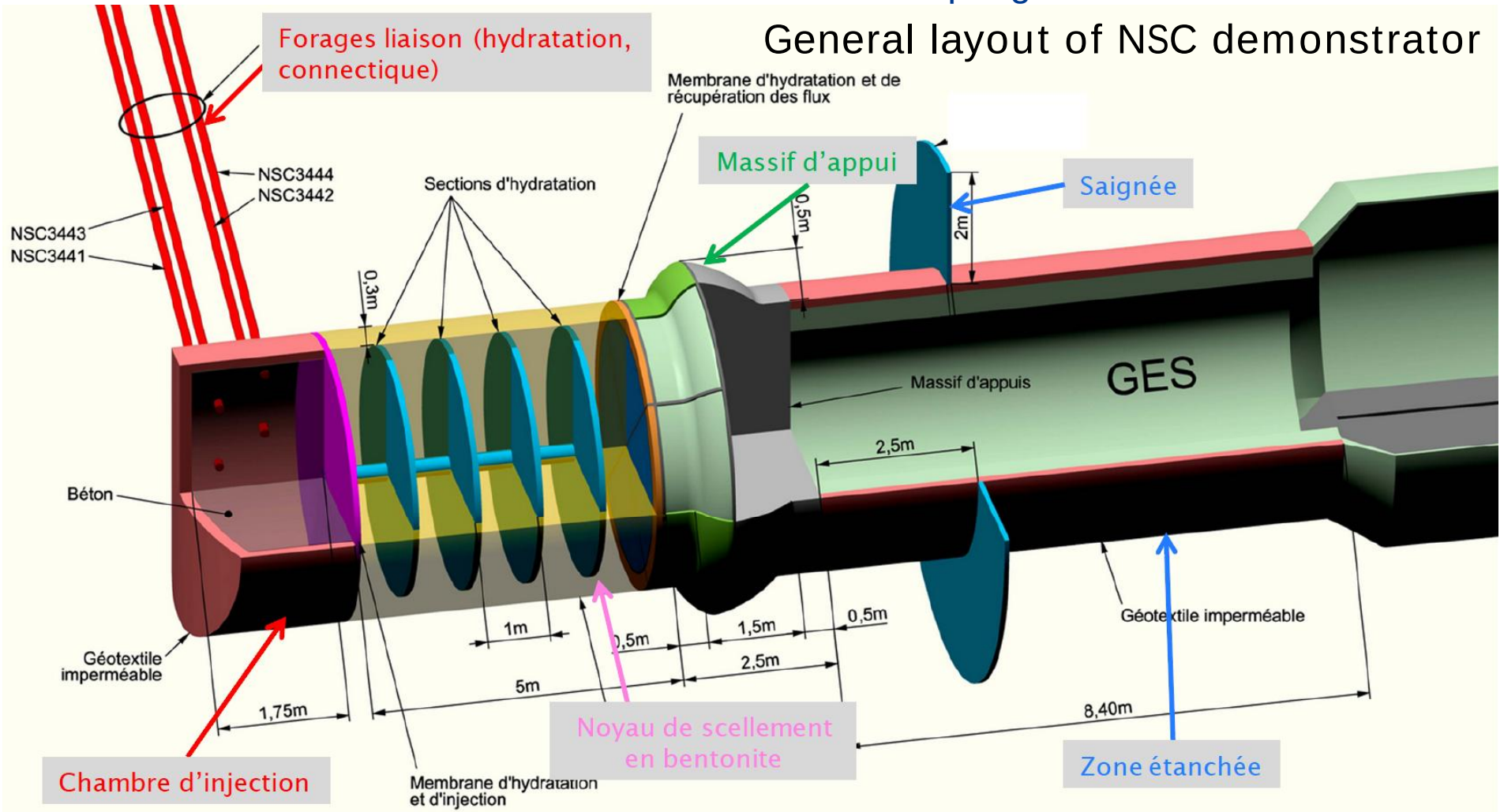
NSC demonstrator (out of DOPAS Project scope)

This underground URL ½ scale experiment aims to evaluate the hydraulic performance of a seal bentonite core and its near field (EDZ) by evaluating the water pathways in the system and its equivalent permeability.



Main demonstrators in the actual program

General layout of NSC demonstrator



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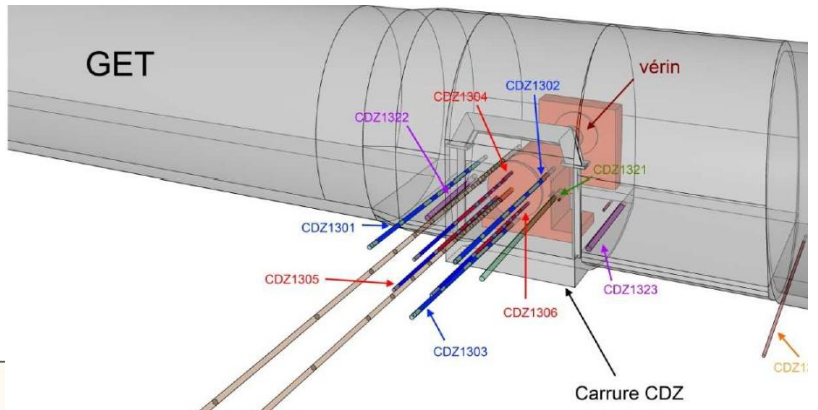
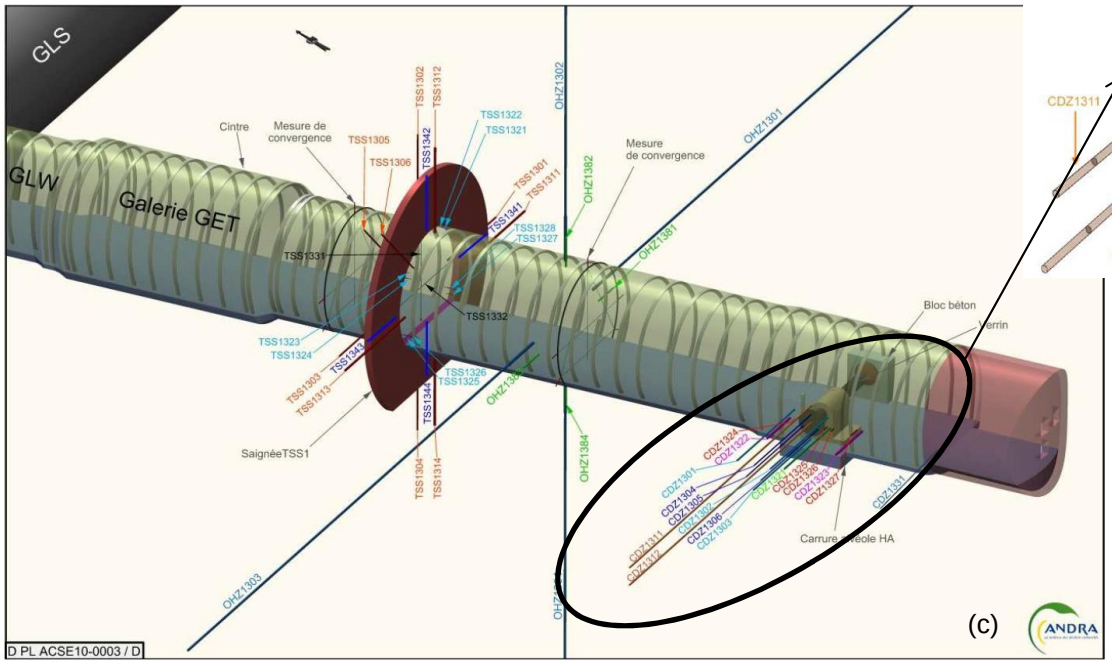
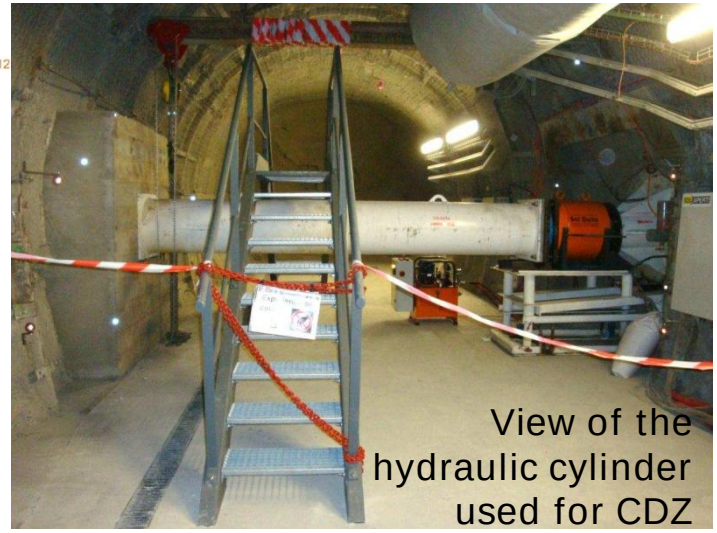
Main demonstrators in the actual program

CDZ demonstrator : recompression of the EDZ

Outside of the DOPAS Project scope





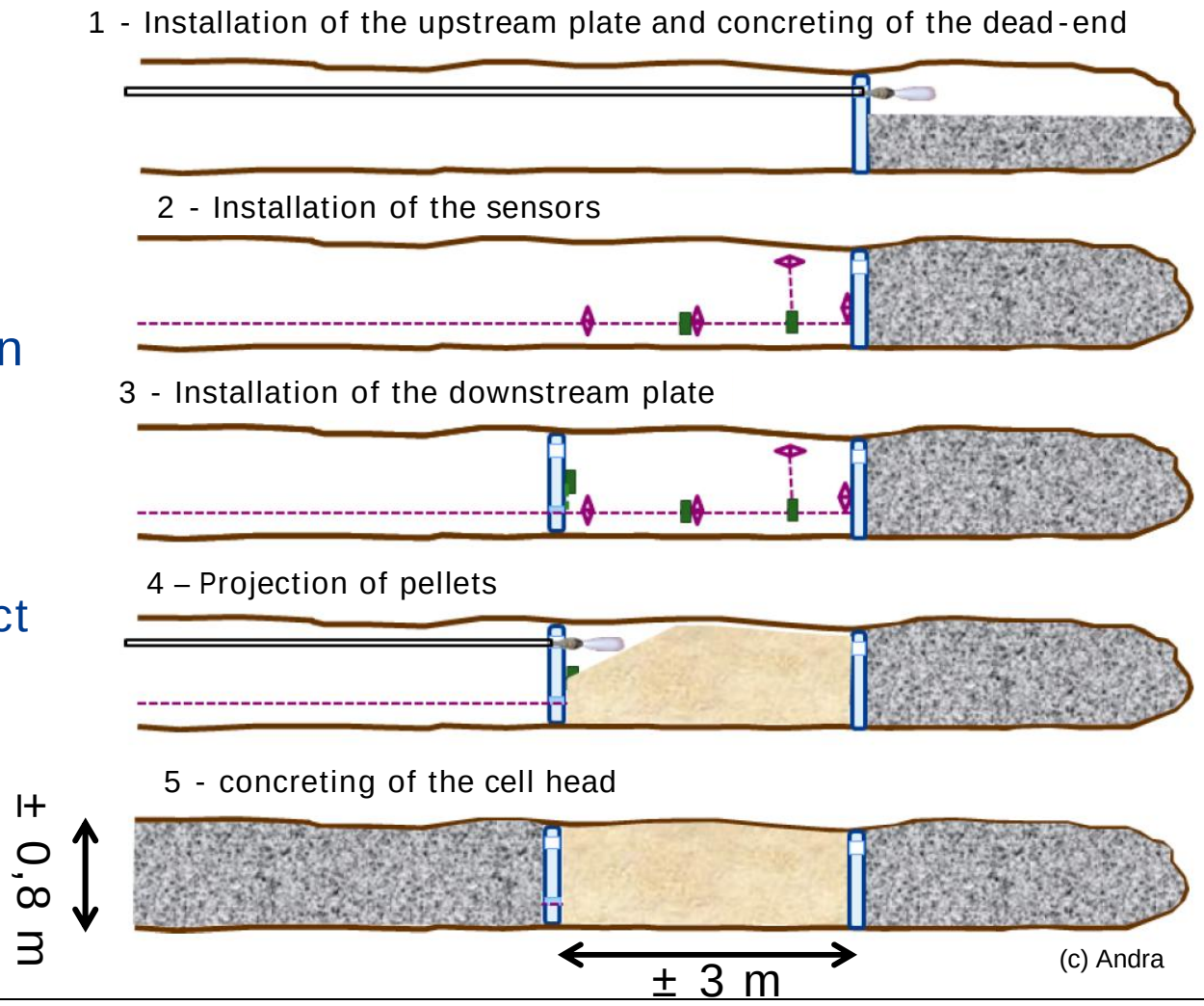

View of the hydraulic cylinder used for CDZ

Main demonstrators in the actual program

BHN demonstrator

- Underground (Bure URL)
- Natural resaturation of FSS bentonite mixture

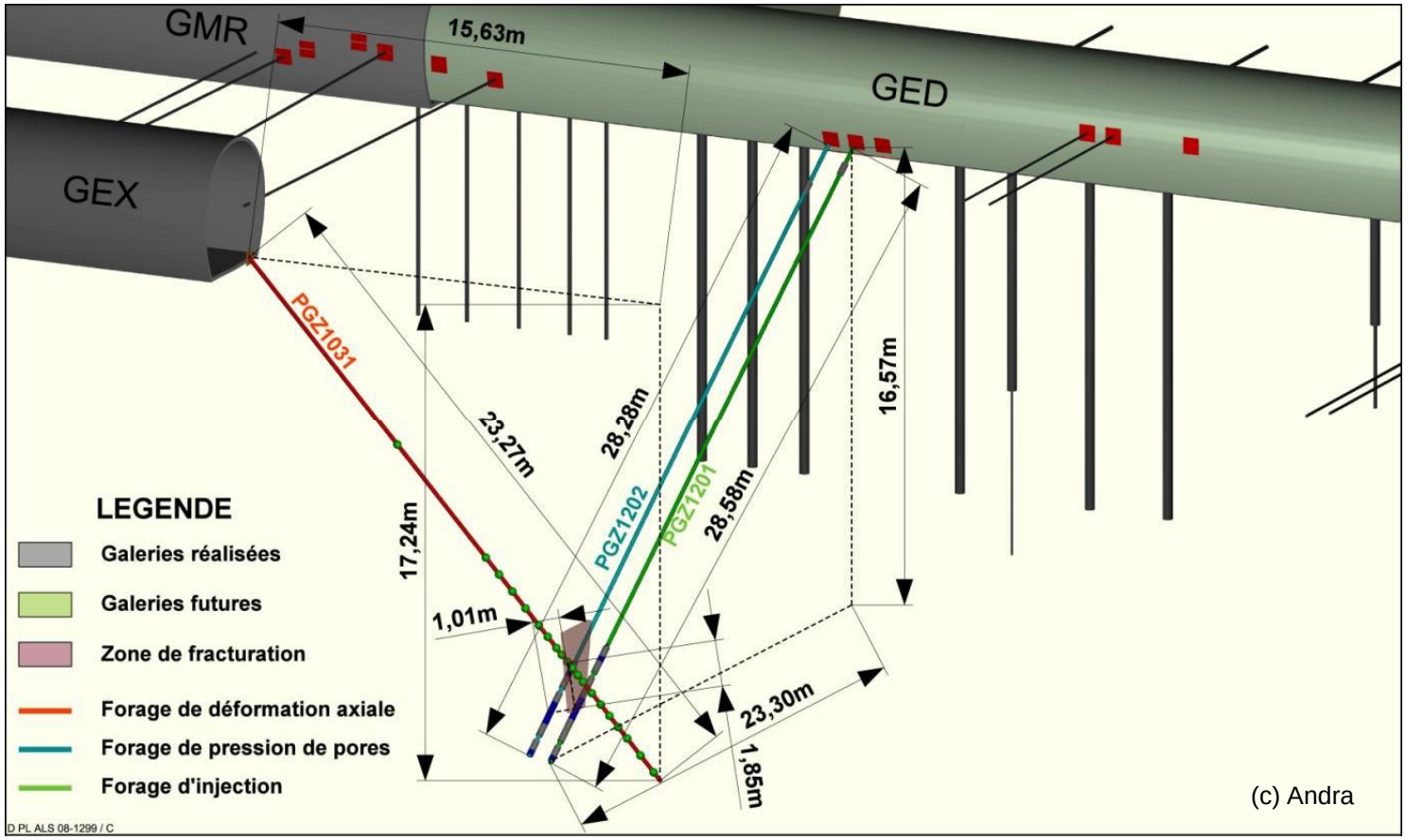
Out of the DOPAS Project scope



Main demonstrators in the actual program

PGZ experiment : in-situ borehole gas injection test

Out of the DOPAS Project scope

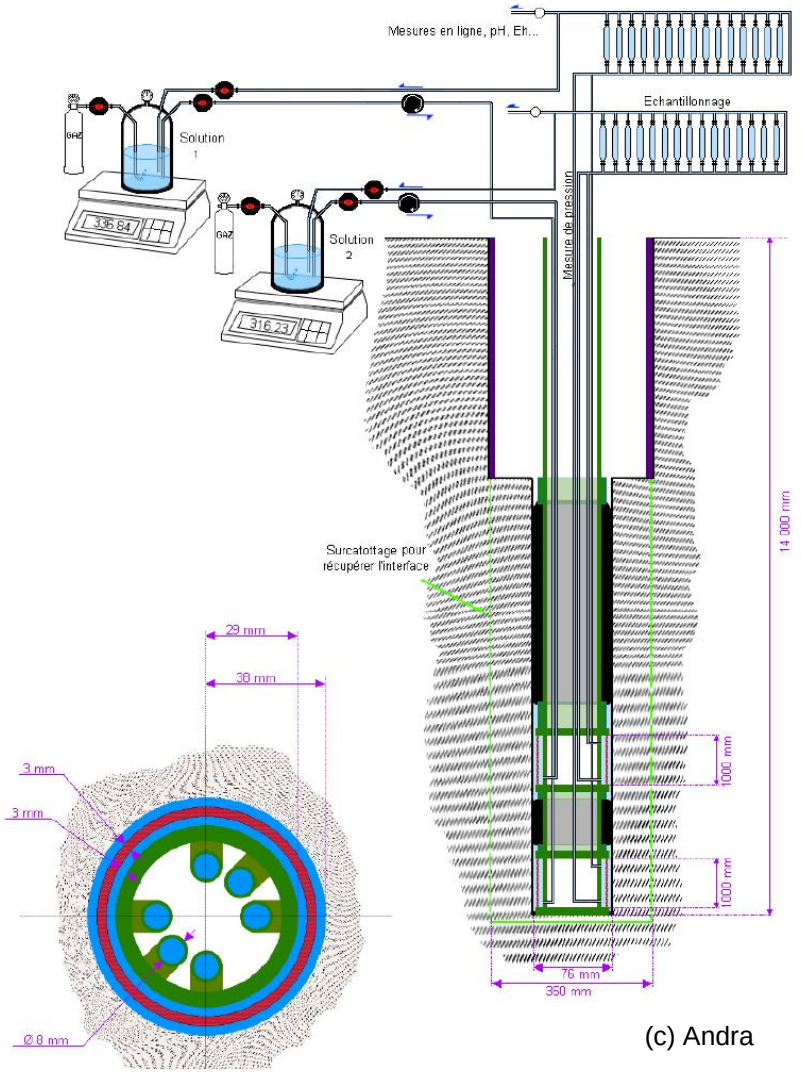


The main demonstrators in the actual program

MLH experimentation

- In situ borehole chemical experimentation.
- Analysis of the evolution with time of chemical composition of a synthetic concrete water in contact with the clay host rock

Out of the DOPAS Project scope



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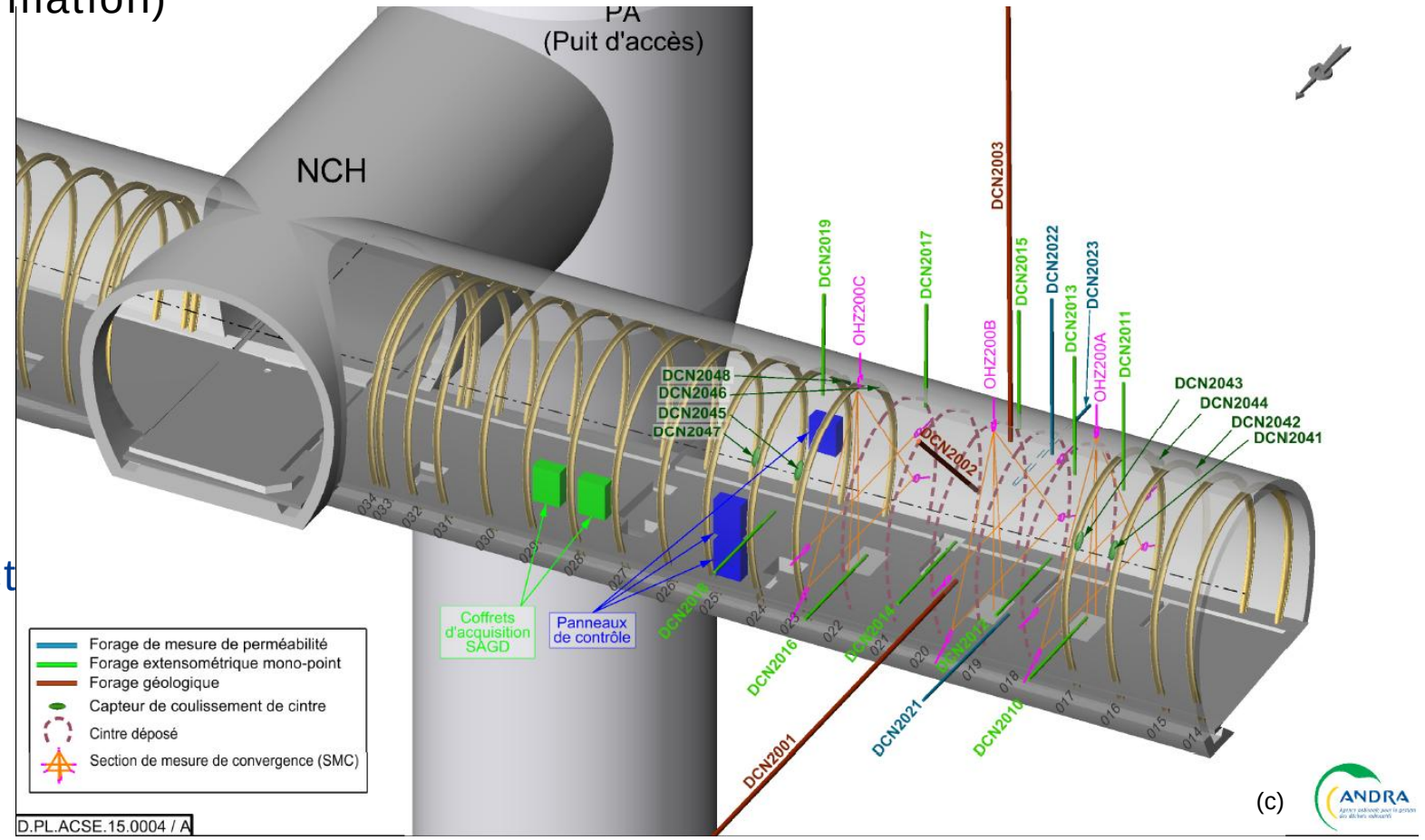
Main demonstrators in the actual program

DCN experimentation : concrete liner removal test (in the upper part of the host rock formation)



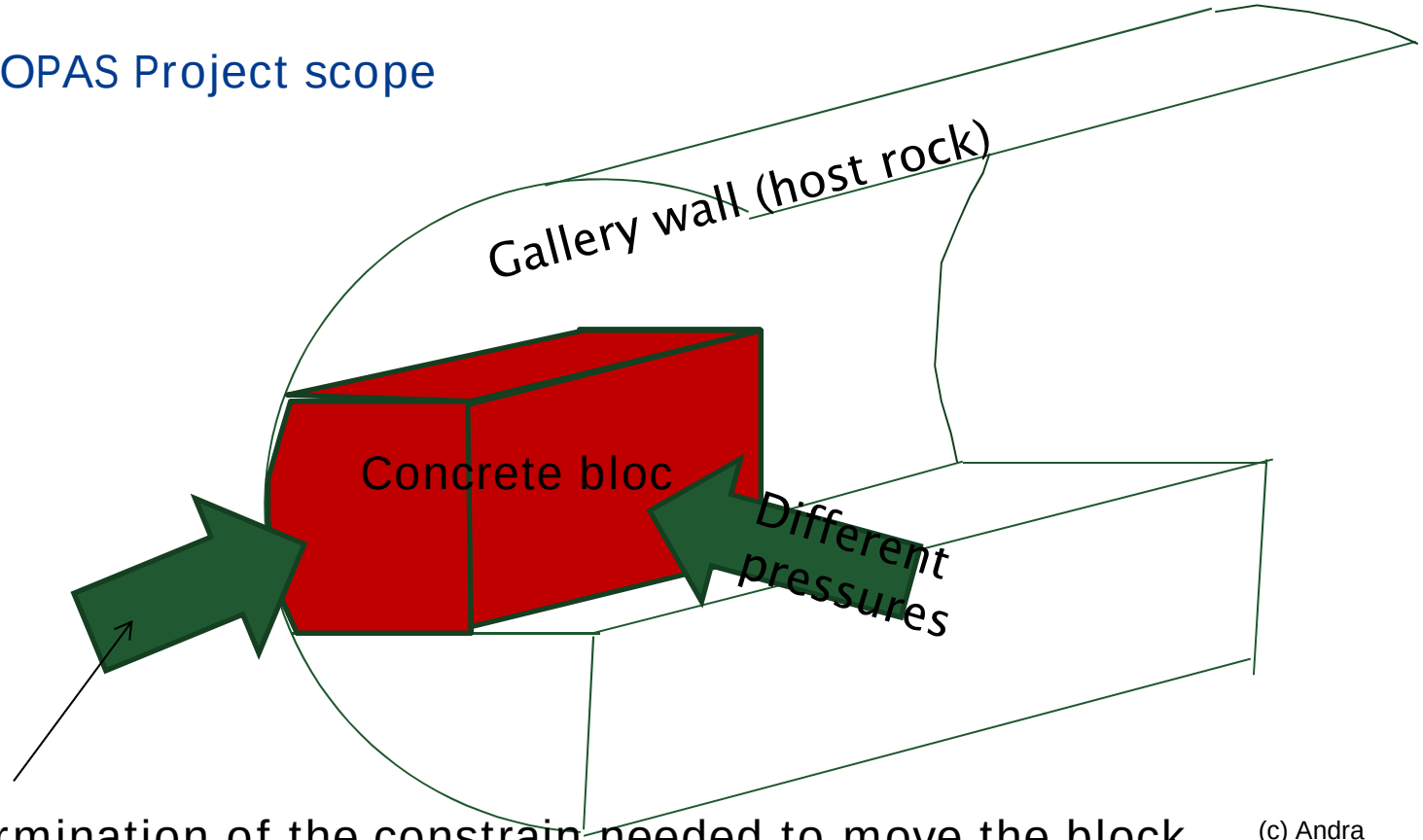
Out of the DOPAS Project scope

Main demonstrators in the actual program

Experimental study of friction and shear conditions of the concrete-clay interface

Out of the DOPAS Project scope

Principle of the experiment



Determination of the constrain needed to move the block

Main demonstrators in the actual program

Numerical simulations of plugs and seals

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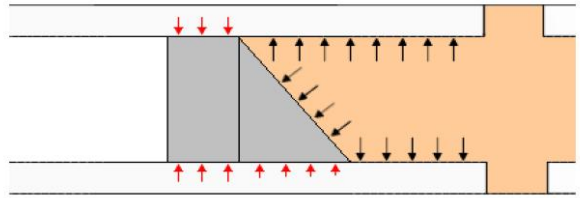
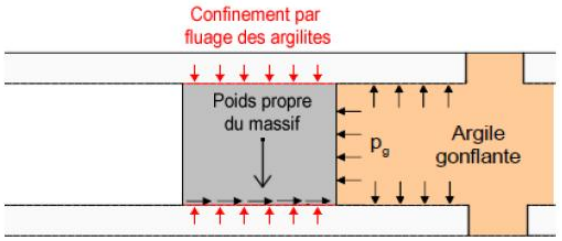
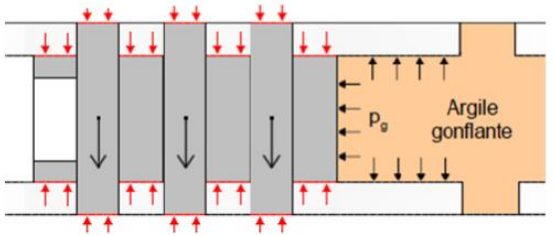
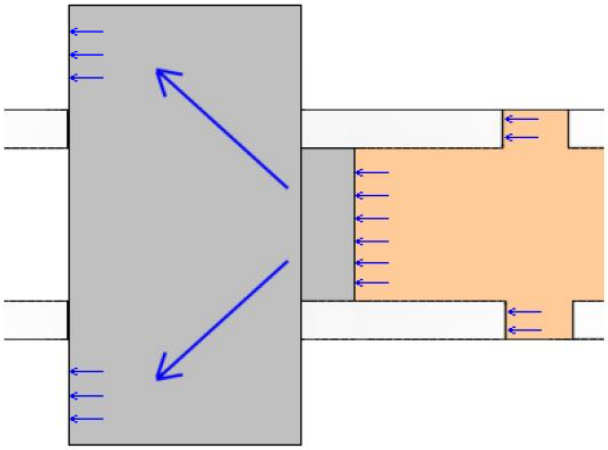
Numerical test of different forms for the concrete containment plug

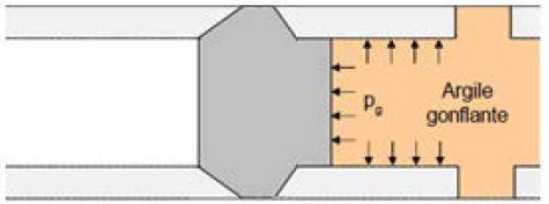
Examples











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Main demonstrators in the actual program

Reactive transport 2D numerical simulations of the interfaces in a seal

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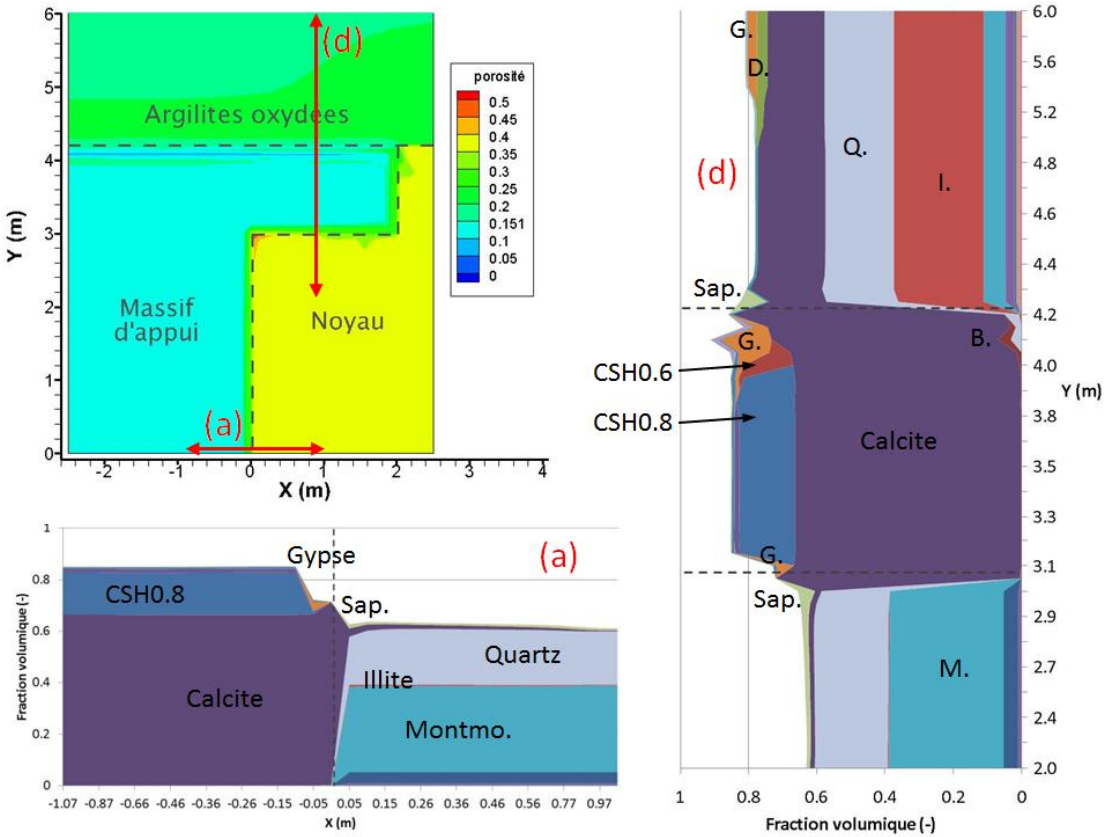
Interfaces bentonite core side



Example of porosity after 100 000 years
G: Gypse, D: Dolomite, Q: Quartz, I: Illite, B: Brucite, M: Montmorillonite, Sap: Saponite

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Main demonstrators in the actual program

Alternative concept : hydraulic cut TSS demonstrators

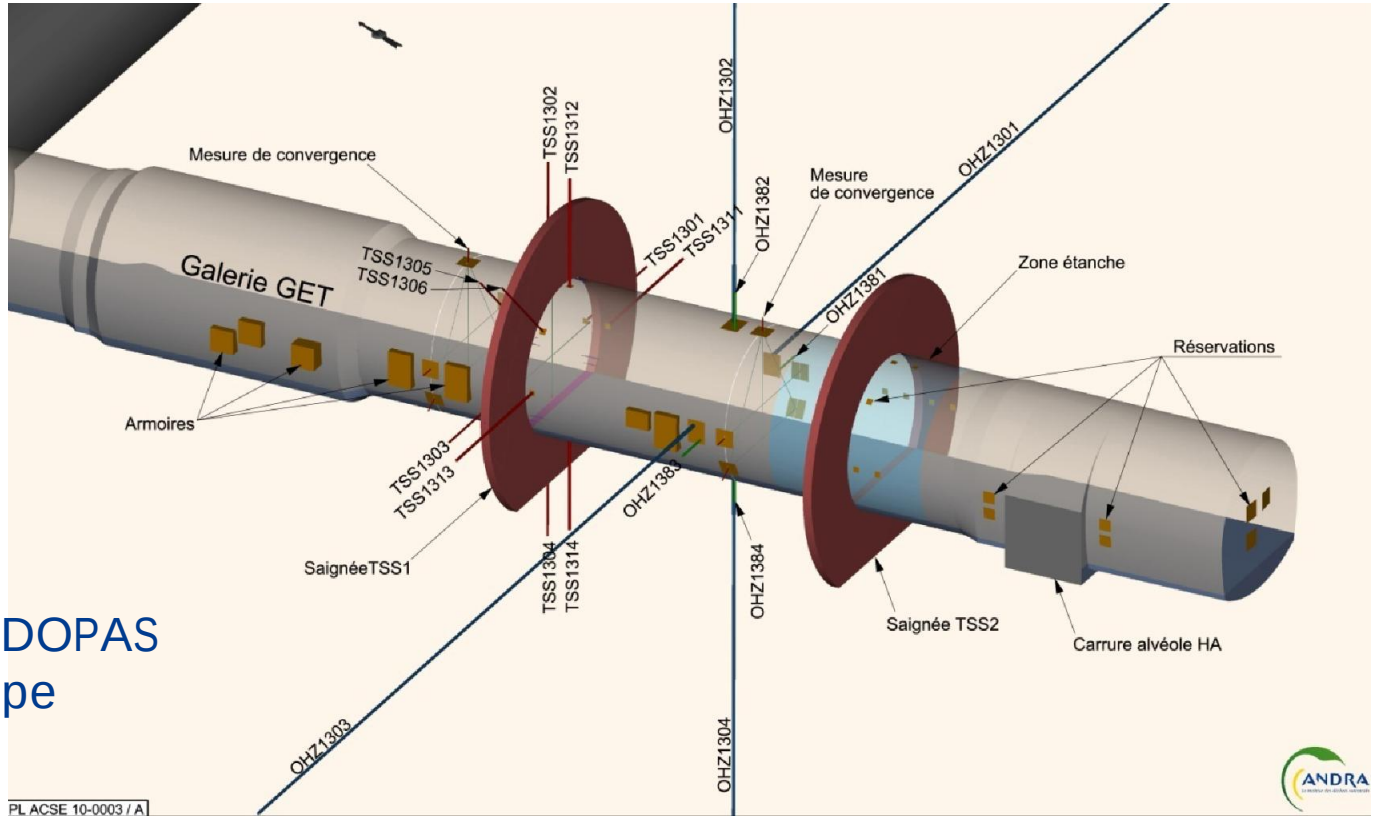
- Surface experiment
- Focused on technical feasibility (robot emplacing the bentonite blocks in the cuts

Out of the DOPAS Project scope

Main demonstrators in the actual program

Alternative concept : hydraulic cuts SET demonstrators

Ø In the URL
Ø Focused on hydraulic performance of the cuts



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Thank You