FULL-SCALE DEMONSTRATION OF PLUGS AND SEALS - DOPAS FP7 PROJECT 2012-2016

DOPAS coordinator,
Johanna Hansen, Posiva

This presentation

- State of the art for plugs and seals development chain
- Main objectives of DOPAS project and few facts about DOPAS project
- DOPAS Experiments and their scope
- The main findings about DOPAS project
- DOPAS Experiments years later

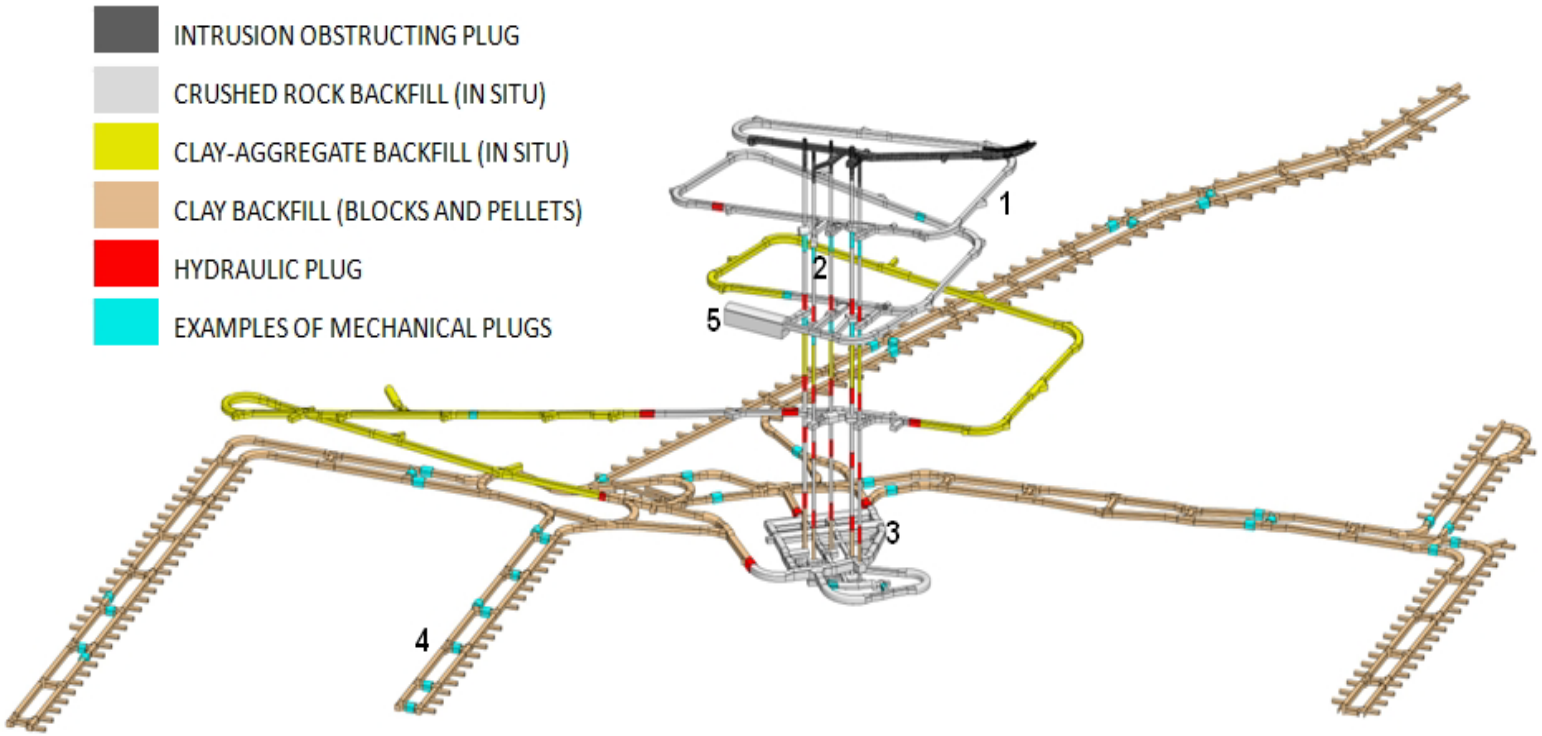
DOPAS = Full Scale Demonstrations of Plugs and Seals

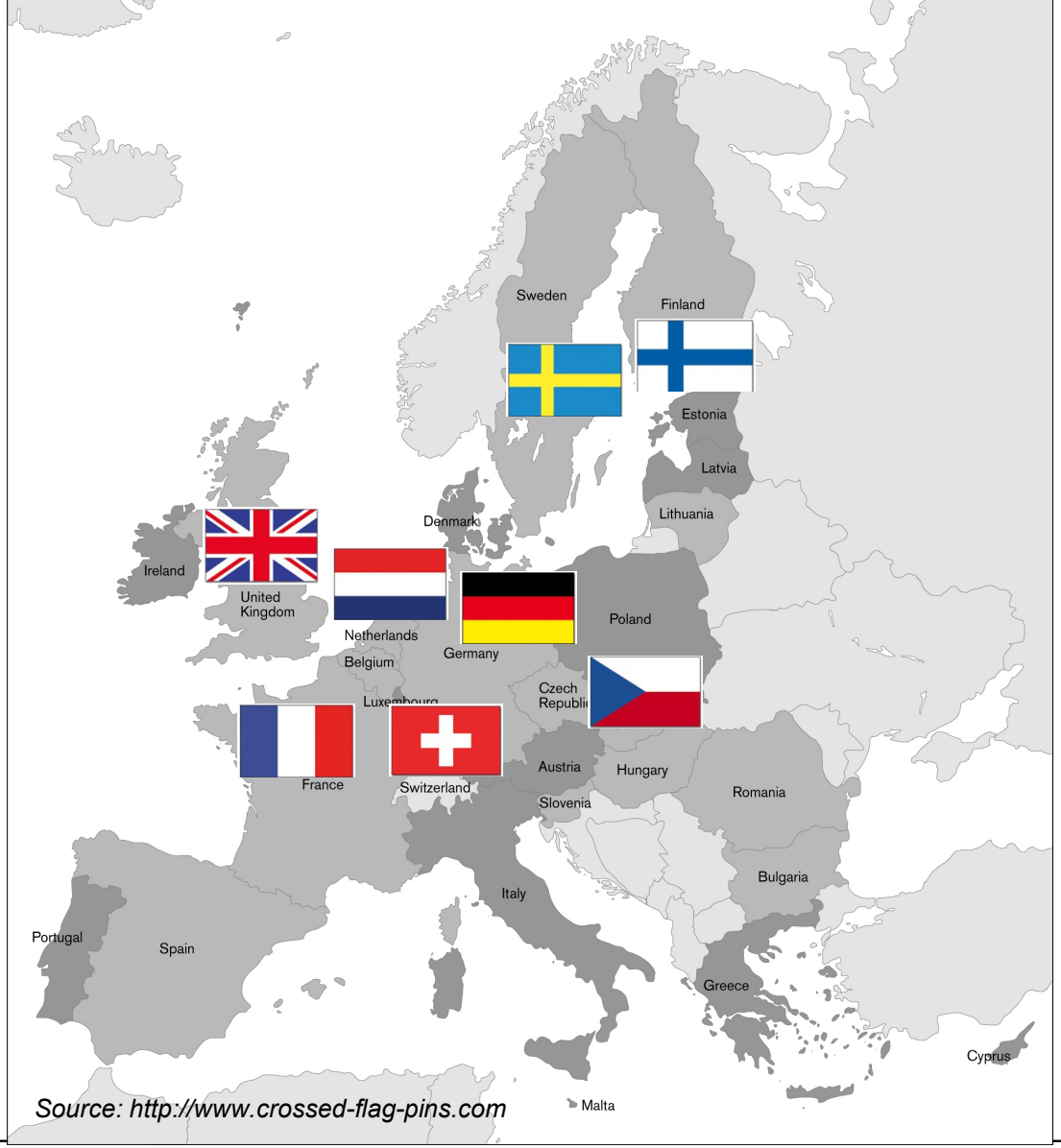
http://www.posiva.fi/en/dopas

State of the art prior DOPAS project

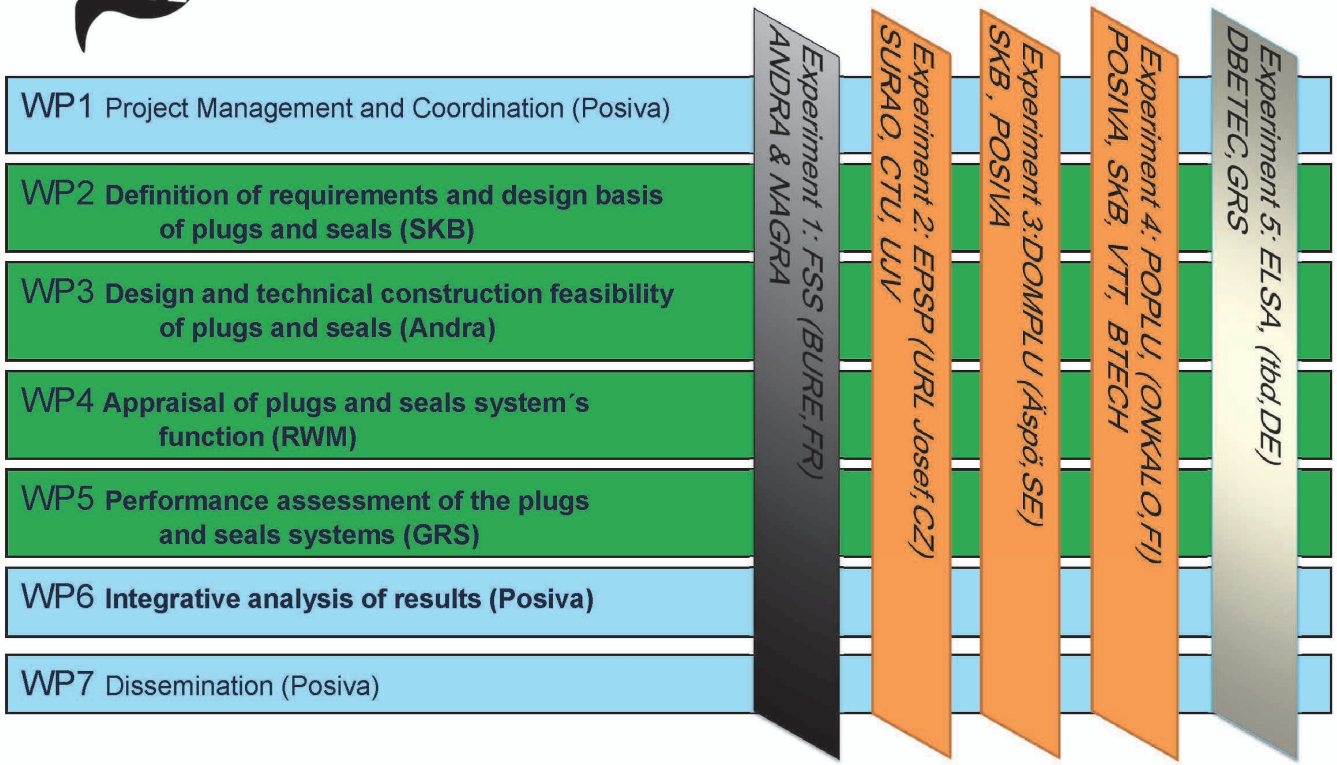
- Support the achievement of Vision 2025 according the IGD-TP SRA deployment
- Open questions:
  - Design basis processes and conceptual designs
  - Siting and excavation of plug/seal locations
  - Installation, monitoring and performance of plugs and seals
  - Compliance of plug and seal designs with their functions

Plugs and seals in repository




Sweden
Finland
Estonia
Latvia
Lithuania
Denmark
Ireland
United Kingdom
Netherlands
Germany
Poland
Belgium
Czech Republic
Luxembourg
France
Switzerland
Austria
Hungary
Slovenia
Romania
Bulgaria
Italy
Portugal
Spain
Greece
Cyprus
Malta
Source: http://www.crossed-flag-pins.com

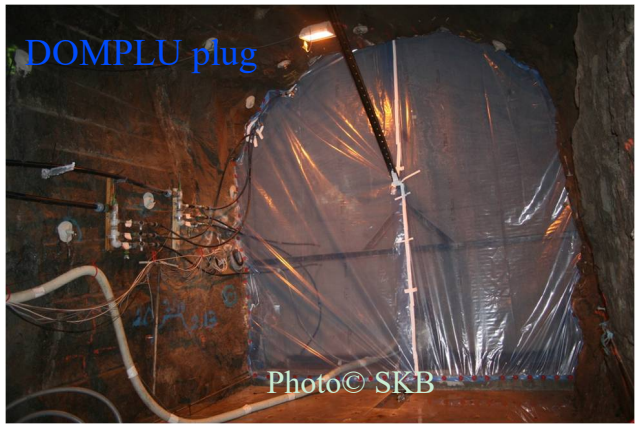
DOPAS Experiments and work packages



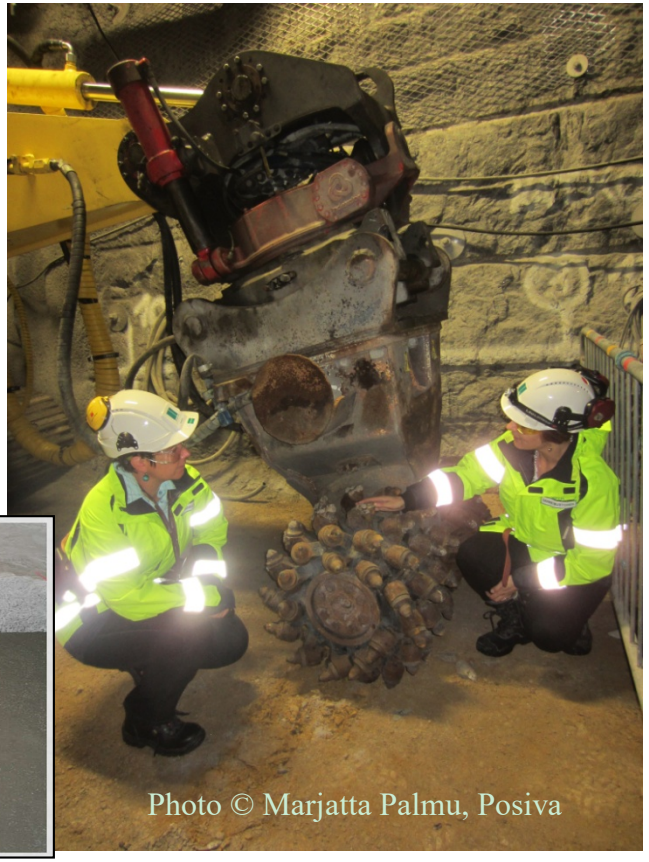
POSIVA nagra. ČVUT FSv NRG ÚJV jed·tp safe solutions for radioactive waste Radioactive Waste Management B+TECH SKB Svensk Kärnbränslehantering AB

SÚRAO DOPAS VTT GRS EURATOM Galson Sciences Ltd DBETEC DBE TECHNOLOGY GmbH ANDRA

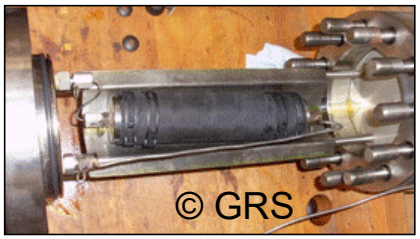
DOPAS Experiments



POPLU grinding of plug location



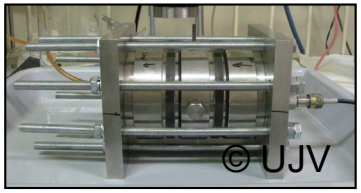
Different scales /concretes



POSIVA nagra. ČVUT FSv NRG ÚJV jgd·tp safe solutions for radioactive waste Radioactive Waste Management B+TECH SKB Svensk Kärnbränslehantering AB

SÚRAO VTT GRS EURATOM Galson Sciences Ltd DBETEC DBE TECHNOLOGY GmbH ANDRA

Different scales /bentonite



POSIVA nagra. ČVUT FSv NRG ÚJV jgd·tp safe solutions for radioactive waste Radioactive Waste Management B+TECH SKB Svensk Kärnbränslehantering AB

SÚRAO VTT GRS EURATOM Galson Sciences Ltd DBETEC DBE TECHNOLOGY GmbH ANDRA

Underground or above ground

POSIVA nagra. ČVUT FSv NRG ÚJV jgd·tp safe solutions for radioactive waste Radioactive Waste Management B+TECH SKB Svensk Kärnbränslehantering AB

SÚRAO VTT GRS EURATOM Galson Sciences Ltd DBETEC DBE TECHNOLOGY GmbH ANDRA

Assessing the experiments

- Description of site constraints and future evolution
- Setting performance requirements
- Theoretical calculations to support the design and implementation phase
  - Model development
  - PA-methodology,
- Processes and phenomena
- Integration of results to the overall safety

Joint aspects and benefits for co-operation with plugs and seals

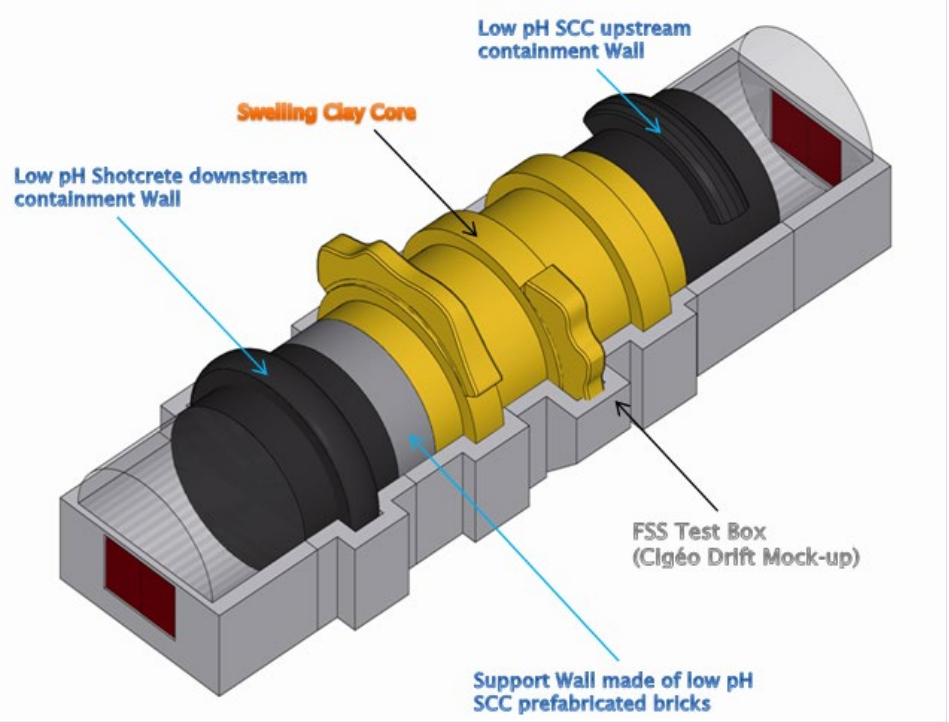
- Preparation for demonstrations before operation phase
- Similar type of materials and methods
- Improved quality and risk management including occupational and long-term safety
- Theoretical calculations to support the design and implementation phase
- Similar work phases is good way of benchmarking how other organisations are working
- The success and challenges are good to discuss and analyse with people having similar experience

DOPAS provides further

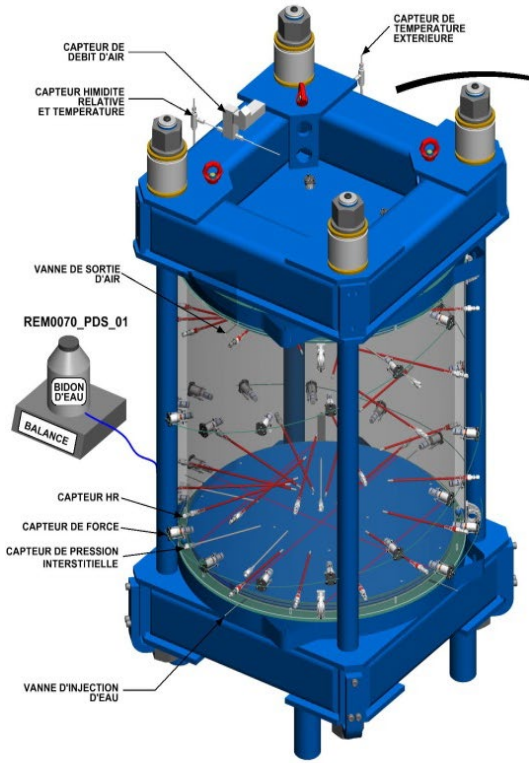
- Developed and described design basis, reference designs and strategies and examples
- Detailed design and implementation chain for different type of demonstrations
- Experiences on materials to be used in repositories and their interactions
- Improved quality and risk management procedures, which has been used in practice
- Experiences on plug performance in different conditions
- Experience on performance assessment tool for plugs and seals
- Role on plugs and seals in Safety case

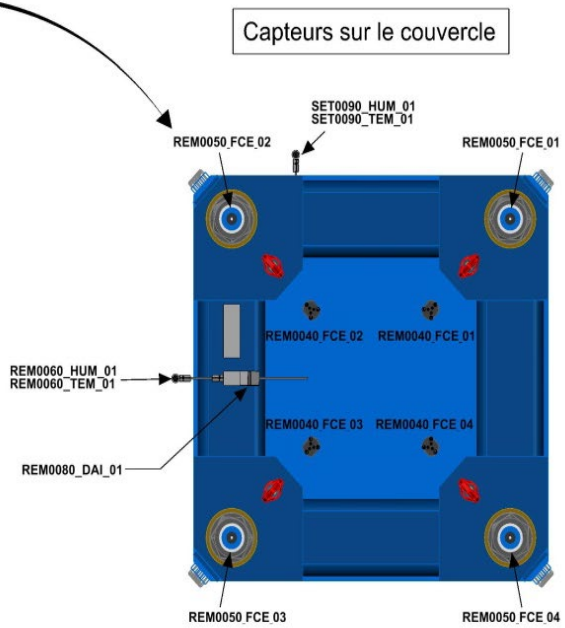
FSS, ANDRA, St. Dizier, FR

- Demonstrate the industrial capacity to emplace large volumes of low pH SCC and shotcrete at a pH value equal or less than 11
- Demonstrate the industrial capacity to emplace large volumes of swelling clay admixture at a specific gravity value above 1.50 g/cm3
- Define operational constraints linked to emplacement activities and compatible with the mechanical or hydraulic properties allocated to the seal components
- Define and operate the commissioning means necessary to check the compatibility of the work during filling operations
- Define and operate the commissioning means necessary to check the compatibility of the work after filling operations



REM TEST – 4 YEARS LATER





Objectives & start-up date

To study at metric scale, the resaturation kinetics and the evolution (with time) of the bentonitic mixture, as used in the "Full scale seal" test (FSS) :

- **Check that the hydraulic behavior involved in achieving saturation is generally uniform at this scale;**
- **Once the mixture fully saturated, check that the hydraulic characteristics (gas entry pressure, water and gas permeability) and mechanical characteristics (swelling pressure) are compliant with Andra sealing specifications and are generally uniform at the test scale.**
- **Hydration launched on 25th September 2015 (injection performed at constant flowrate of 50 ml per and constant pressure)**

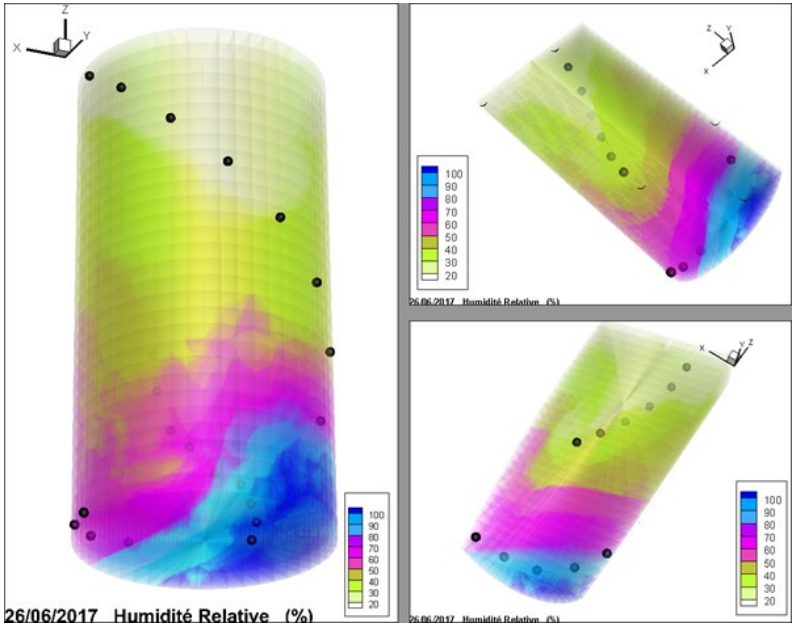
Results at early stage (4 years)

55 liters of water injected in 4 years

- **300 liters necessary for the total saturation**

Hydration is heterogeneous

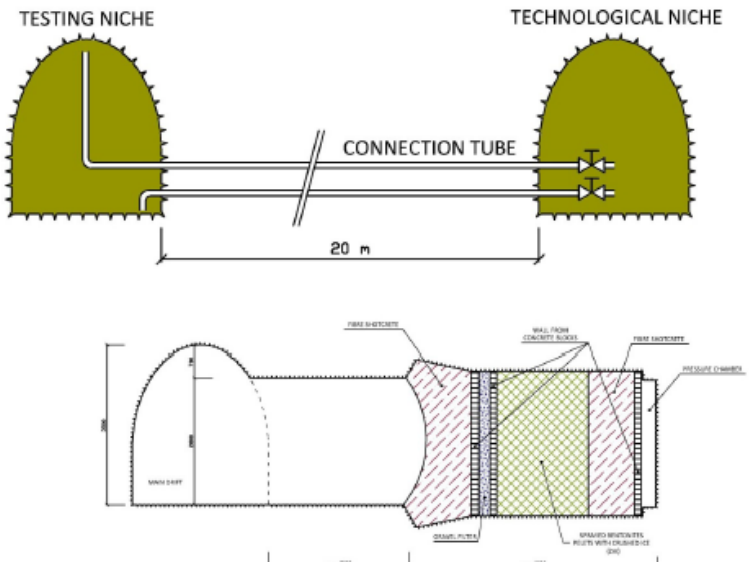
- **Only some humidity sensors (closest to the bottom of the tank) reach 100% saturation, while in the upper part sensors have not exceeded 40 %**
- **Pore pressure and total pressure values have no physical significance for the moment and confirm that the mixture is not saturated**

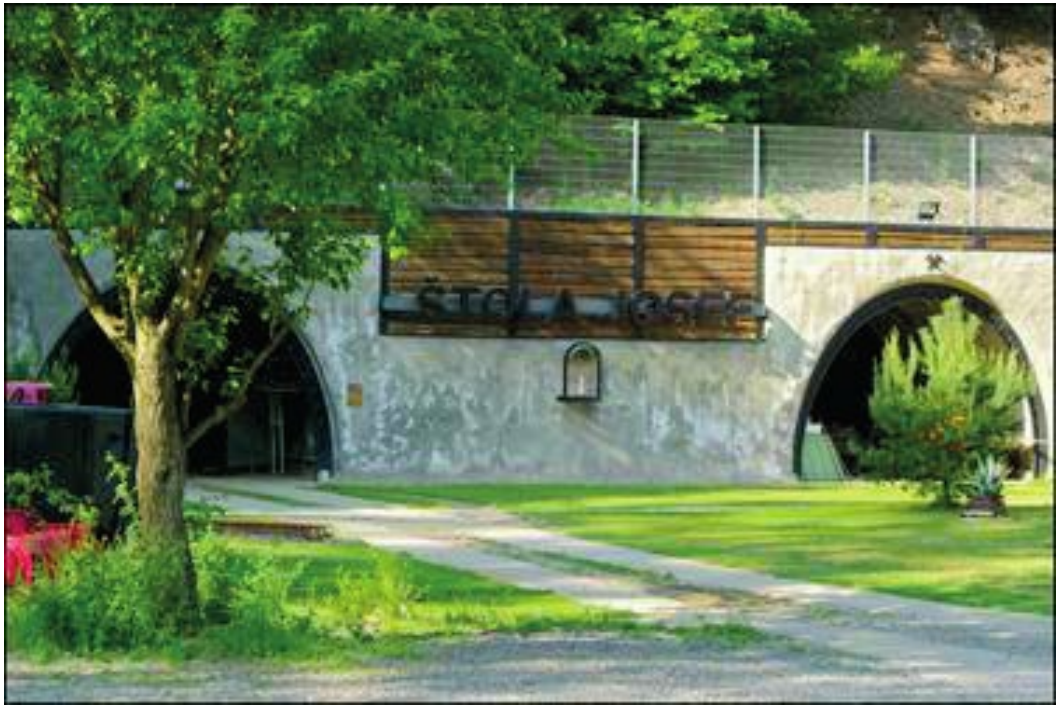


3D Interpolation of relative humidity measurements at 1000 days

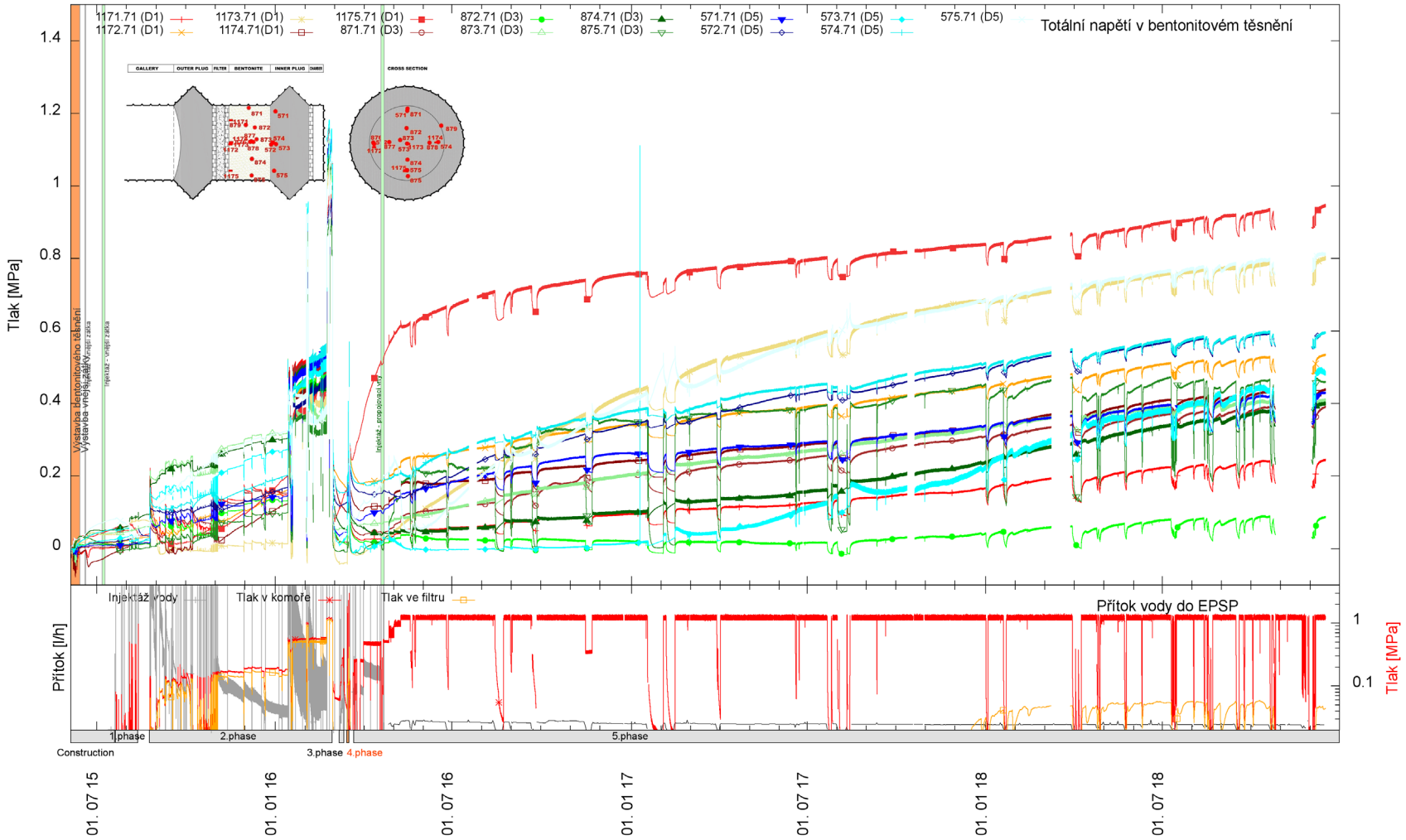
Estimate: 30 to 60 years to reach total saturation (twice what was anticipated)

EPSP, CTU, Josef gallery, CZ

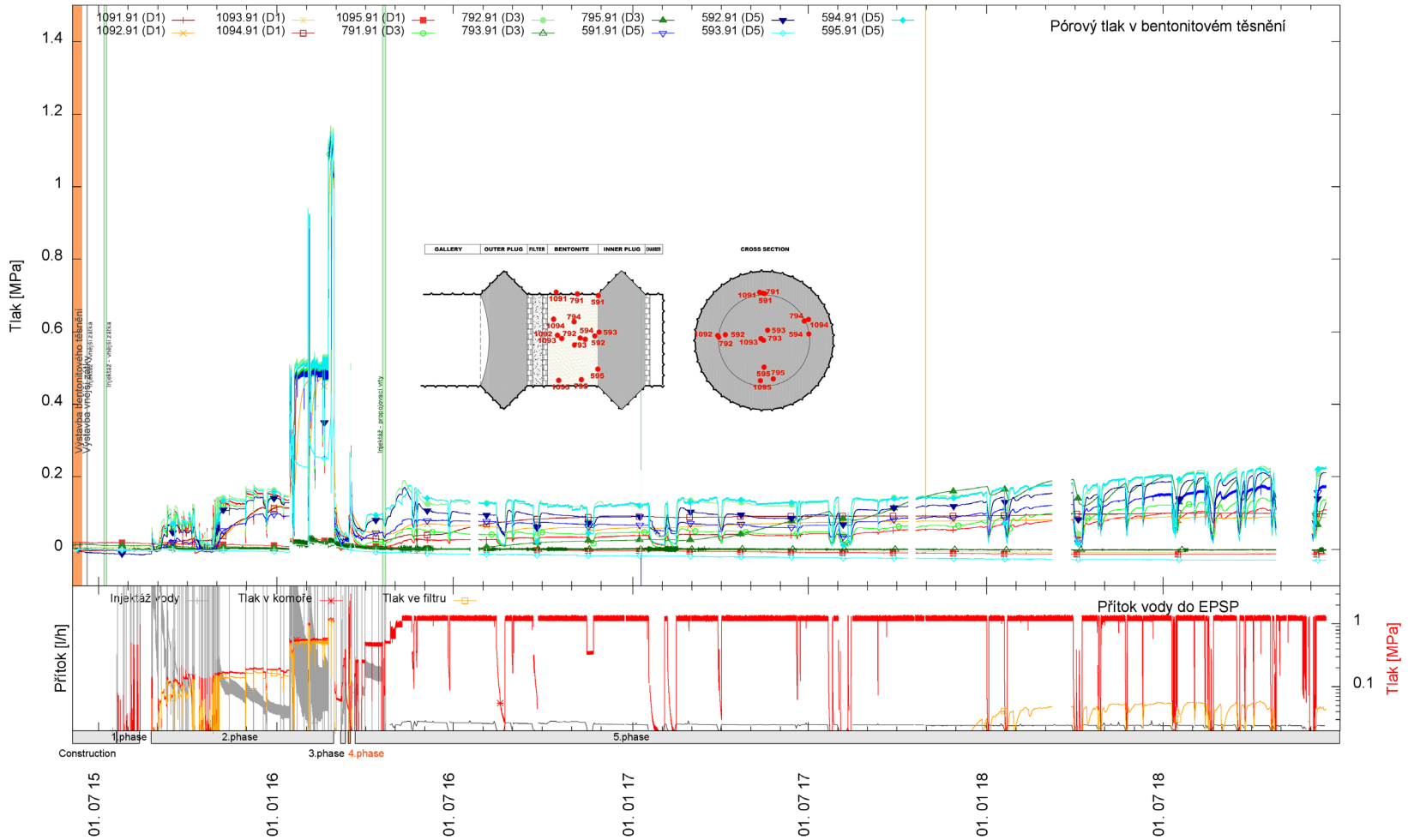




EPSP 5 years later

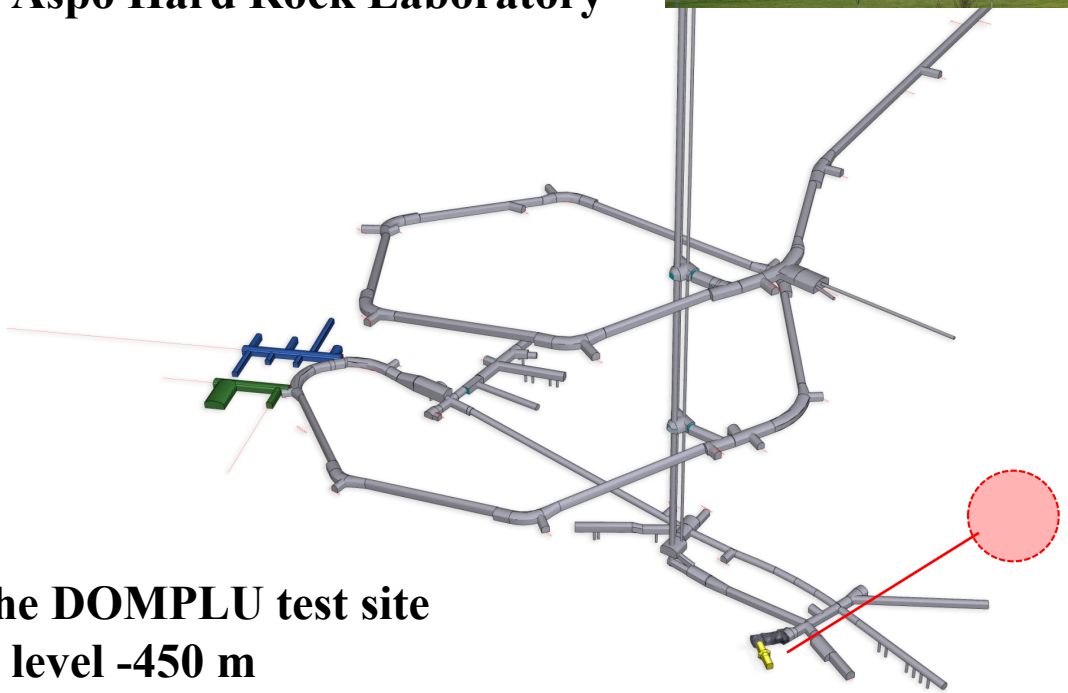


EPSP 5 years later



DOMPLU, SKB, ÄSPÖ, SE

The DOMPLU test is carried out at Äspö Hard Rock Laboratory

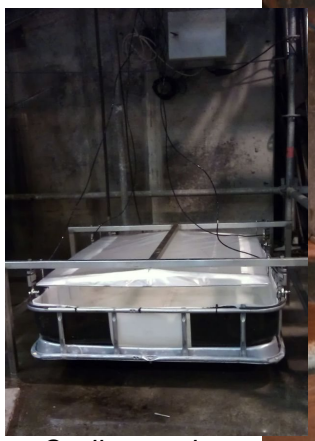


The DOMPLU test site at level -450 m

The trial is pressurized partly with the help of the prevailing groundwater pressure at 450 meters depth and partly by water pumped into the backfill and filter behind the plug.

DOMPLU – Leakage measurements

- DOMPLU was monitored 3 years (2013-2016) at a constant water pressure of 4MPa. During this period the leakage past the plug varied between one and two litres per hour (17-33 ml/min). This can be considered as an upper limit of the expected leakage of the DOMPLU plug design (artificial pressure was higher than groundwater pressure)

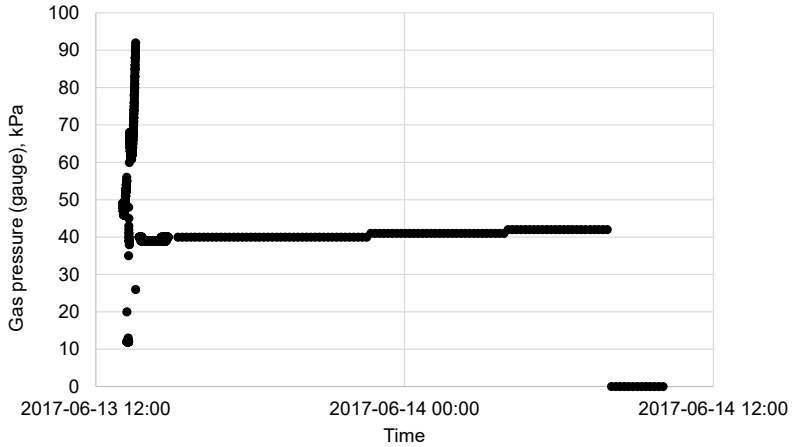


On-line scale for seepage

DOMPLU – Gas tightness test

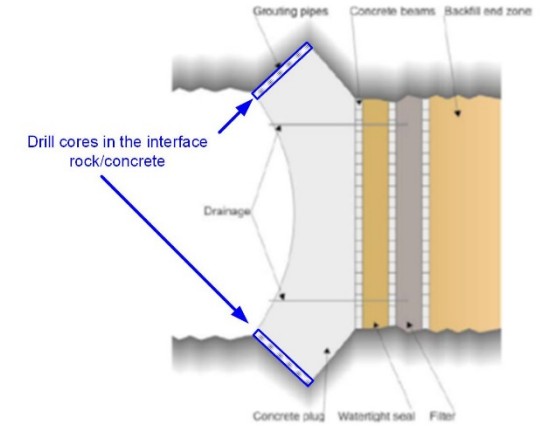
- Swedish/Finnish requirement states that plugs must be reasonably gas tight during the operation phase of the Spent Fuel Repository
- In 2017, the DOMPLU plug was drained and a gas tightness test was performed by injecting helium to a pressure of 40 kPa in the filter section. The plug proved to be completely gas tight at this pressure!

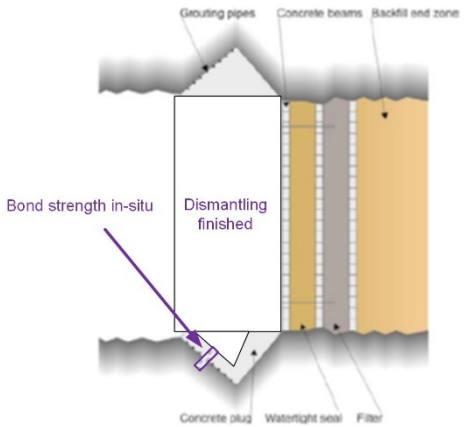
Helium sniffer leak search in June 2017. No track of gas could be detected on the downstream side of the dome!

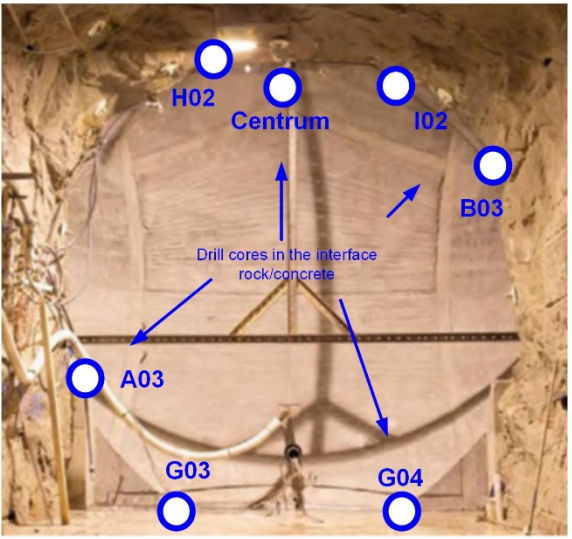


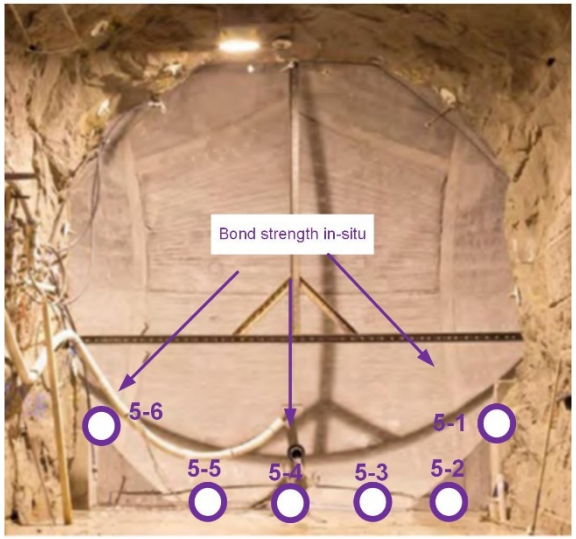
Recorded gas pressure during the gas tightness test

DOMPLU – Strength test and dismantling



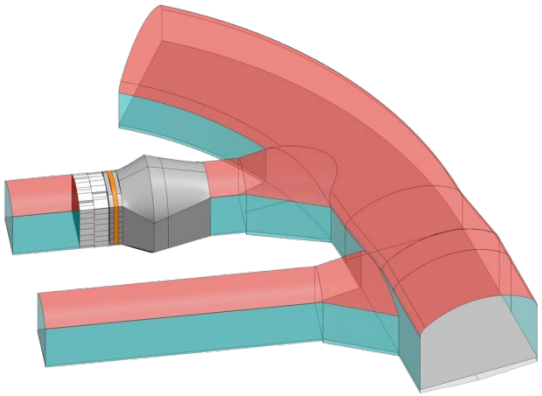


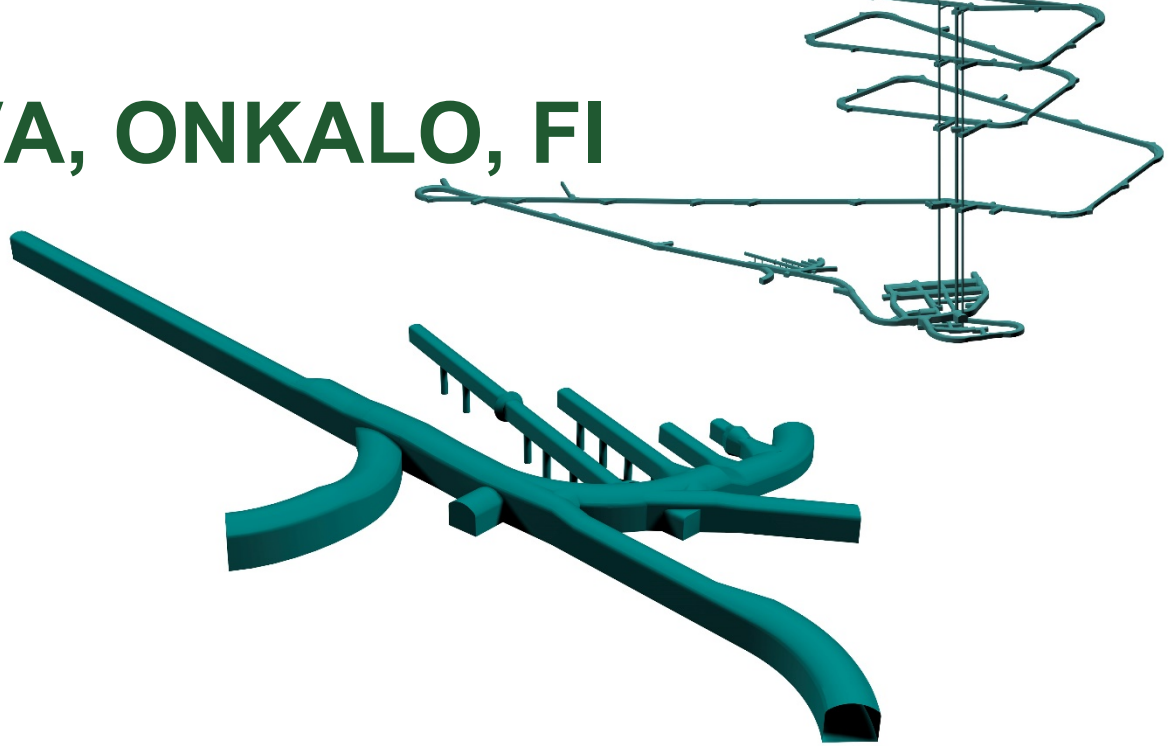




- In the final strength test, water was injected to a total pressure of 10 MPa. The concrete dome behaved as expected at this load and deformations did not result in significant cracking or damages within the concrete dome.
- During demolition, great experience was obtained from material test sampling of concrete and bentonite.

POPLU, POSIVA, ONKALO, FI





- Construct a full-scale deposition tunnel end plug (workmanship and quality control)
- Develop the detailed structural design, including development of the concrete mix
- Develop tunnel plug location excavation
- Produce a quality manual for quality control practices and risk mitigation measures
- Develop instrumentation and performance monitoring techniques (mechanical load transfer, concrete shrinkage, water tightness), including models
- Observe and solve practical challenges prior to construction and implementation, related to occupational safety, documentation, quality assurance, practical work procedures etc.

POSIVA nagra. ČVUT FSv NRG ÚJV jed·tp safe solutions for radioactive waste Radioactive Waste Management B+TECH SKB Svensk Kärnbränslehantering AB

SÚRAO VTT GRS EURATOM Galson Sciences Ltd DBE TECHNOLOGY GmbH ANDRA

POPLU and FISST Plug

- After the pressurisation of the POPLU in spring 2016 Posiva started to prepare for the further development of the end plug design
- The aim was to construct Posiva's next plug for the FISST-test (Full-Scale In-Situ System Test) in 2019
- Before the further development of the plug design, Posiva performed a comparison of the results and experiences of the POPLU and DOMPLU tests
- Based on the comparison Posiva wanted to test the DOMPLU type dome plug design in full scale test, since wedge plug was already tested
- The main reasons for this were the smaller amount of concrete and construction feasibility of the dome plug design (casting in one piece vs. in two)

POPLU followed by FISST plug

Sisäinen

DOPAS foreground and dissemination

- Each experiment produced a public summary report
- Integration of experiments presented in Work Package summary reports and DOPAS Technical summary
- Staff exchange programme
- Main DOPAS events:
  - Training workshop September 2015
  - DOPAS 2016 seminar May 2016
    - focusing on plugs and seals and the lessons learned around DOPAS demonstrations

DOPAS project experiences

- Integration between Experiments and Work Packages:
  - requires regular discussion between Exp. leaders and WP leaders (Work Package and management team meetings)
- Full scale demonstrations requires more resources (cost & personnel) than expected, but demonstrations are essential from learning and training point of view
- The DOPAS staff exchange programme has been useful
- Expert Elicitation process for summary reports has been found very useful
- Main reports D6.4; D5.10; D4.4; D3.30; D2.4

DOPAS

www.posiva.fi/en/dopas

The research leading to these results has received funding from the European Union's European Atomic Energy Community's (Euratom) Seventh Framework Programme FP7/2011-2013, under Grant Agreement No. 323273 for the DOPAS project