INCOMAND AND ANCHORS

General overview of bentonite in EBS: purpose, properties, experimental difficulties, heterogeneities…

Topical session 2 – Dublin 09/09/2026

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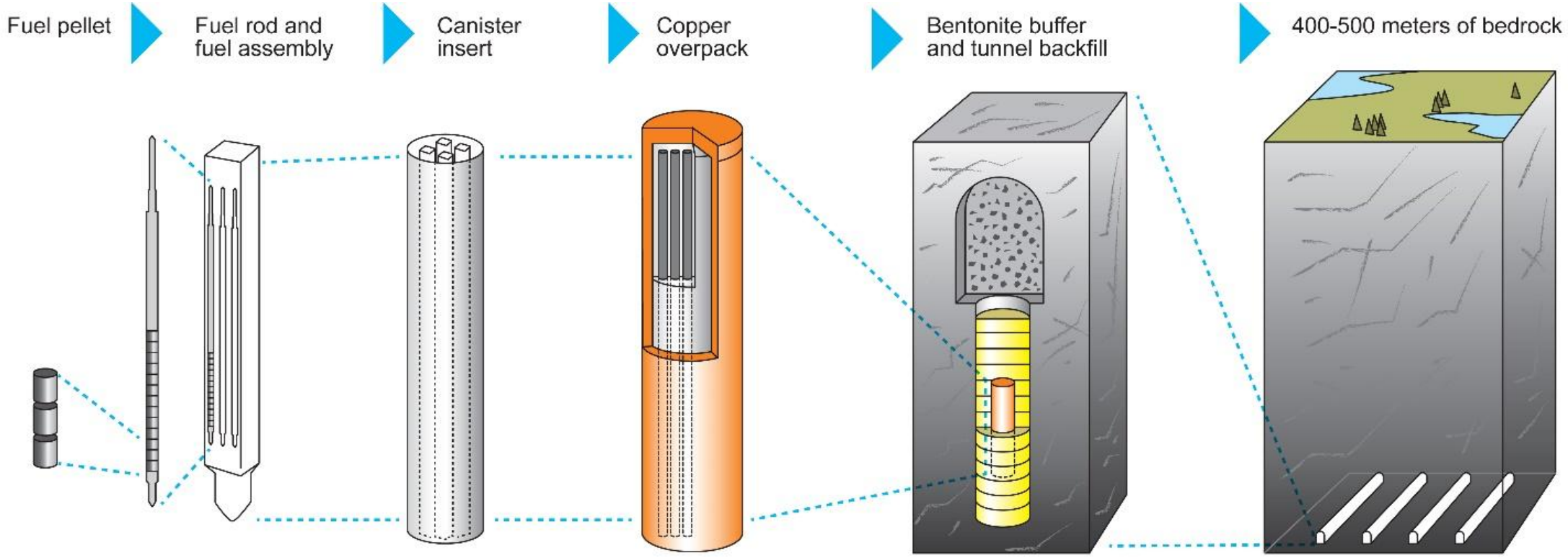
BENTONITE AS PART OF THE ENGINEERED BARRIER SYSTEM

Example of the KBS-3V in crystalline rocks:

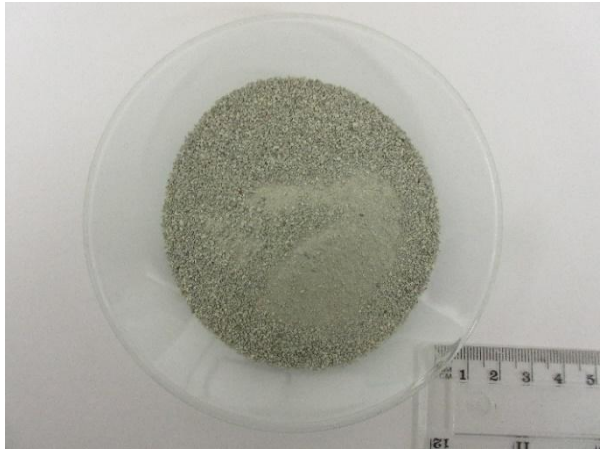


InCoManD

ANCHORS

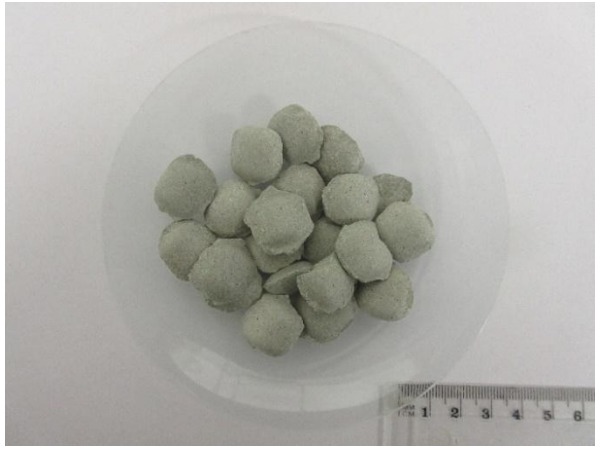
BENTONITE AS PART OF THE ENGINEERED BARRIER SYSTEM

Bentonite in different formats:



Raw bentonite

Pellets Posiva



Pellets SKB

Crushed pellets

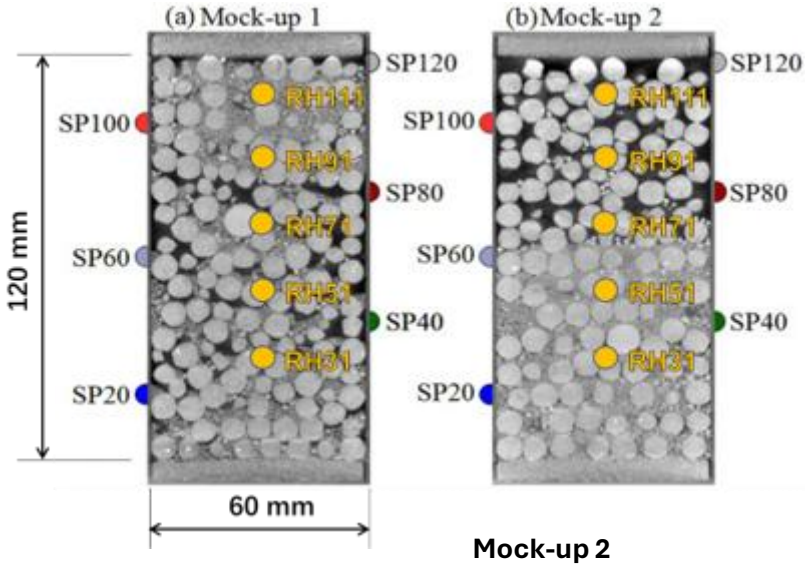
Blocks production

FEBEX assembly: 1996

FEBEX decommissioning: 2015

BENTONITE AS PART OF THE ENGINEERED BARRIER SYSTEM

Mixtures of bentonite and sand / crushed rock:

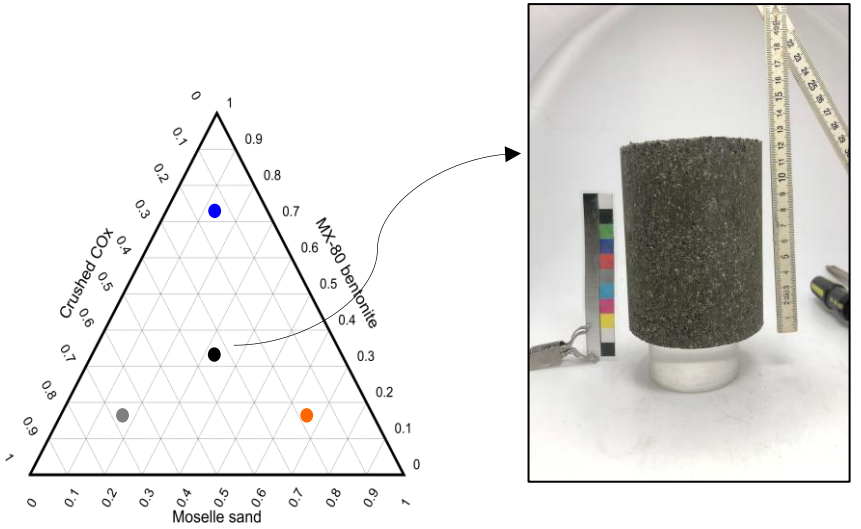


Mock-up 1
"Uniformly" mixed

Mock-up 2
Upper: pellets
Lower: pellets + powders

Powder and pellets. CNRS-NAVIER

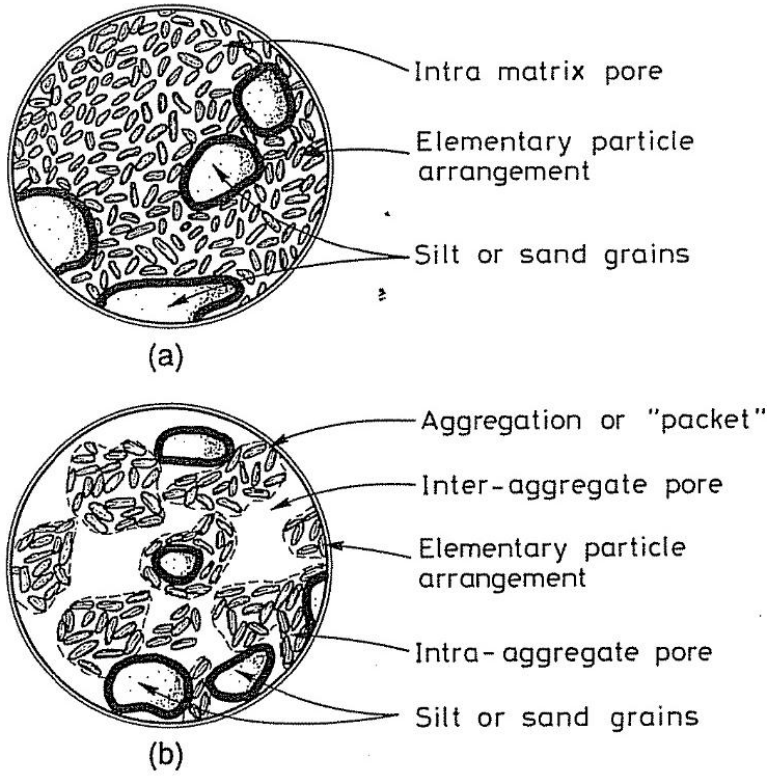
Sand + bentonite. ASRN



Crushed rock + bentonite + sand. EPFL

BENTONITE PROPERTIES

Bentonite composition:



Gens and Alonso, 1992

Wyoming bentonite (sodium bentonite):

Parameter	Required value	Average values
Smectite content (%)	75-90	83.3 ± 2.9
Cation exchange capacity (eq/kg)	-	0.884 ± 0.054
Liquid limit (%)	-	524 ± 27
Plastic limit (%)	-	50
Solids density (kg/m^3)	-	2 782 ± 0.005
Specific surface (m^2/g)	-	627 ± 7
Organic matter (%)	<1	0.15 – 0.58
Sulphide	<0.5	0.04 – 0.09
Sulphur	<1	0.23 – 0.32

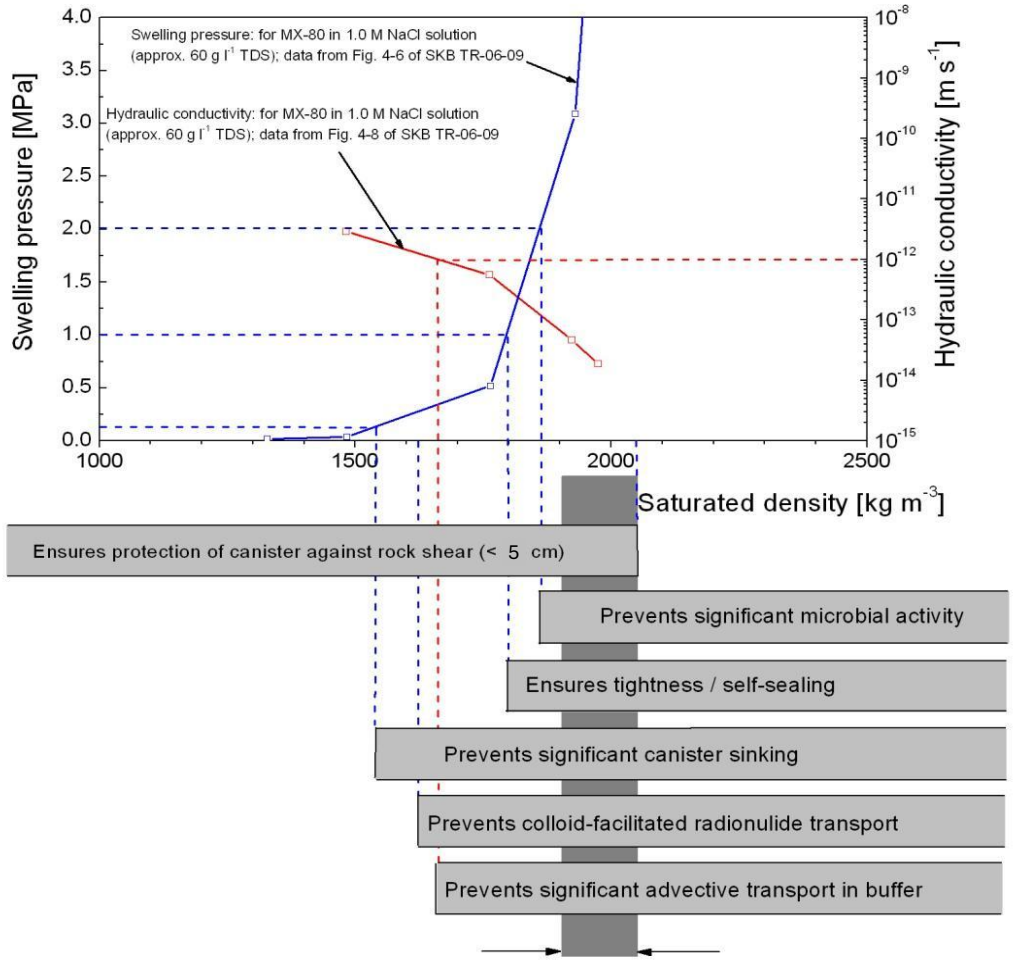
Calcium and bivalent (Calcium and Magnesium) bentonites

BENTONITE PROPERTIES

Properties of the bentonite:

Density requirements

Performance target. How?

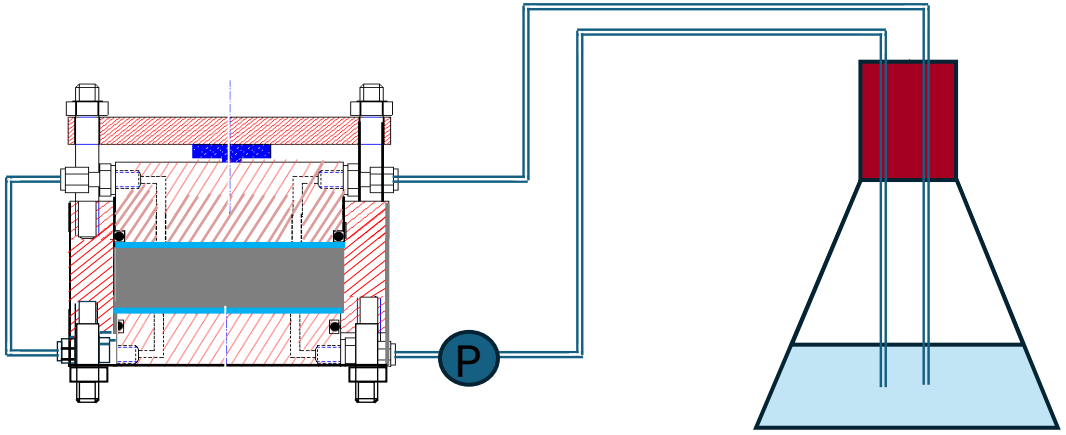


Range of saturated buffer densities ensuring all density-related performance targets are met (lower bound conservatively rounded up to 1900 kg m^{-3})

Safety function. What?

BENTONITE CHARACTERIZATION

Swelling pressure tests: Different types of water.



Saturation process. Clay Technology

Change of the swelling pressure and the hydraulic conductivity with the water composition

Low hydraulic conductivity ⟶ Long tests

Chemical changes ⟶ Long tests. Special cells (corrosion)

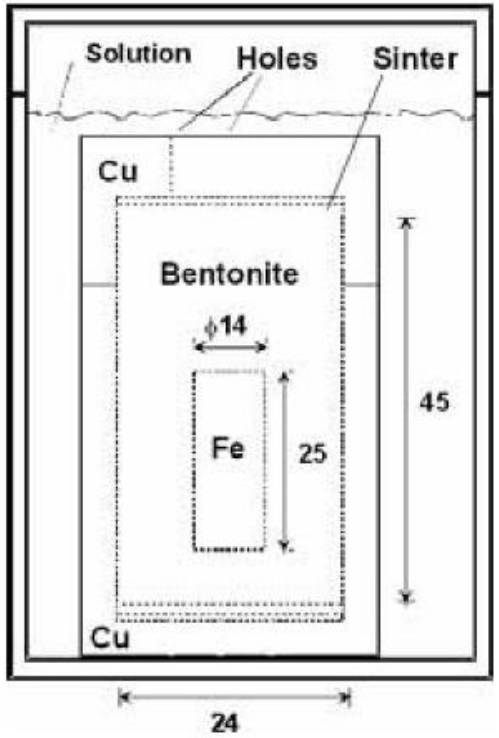
Repeatability: Standards. Benchmark

ANCHORS: Alkalinity (concrete components) and salinity (groundwater)

BENTONITE CHARACTERIZATION

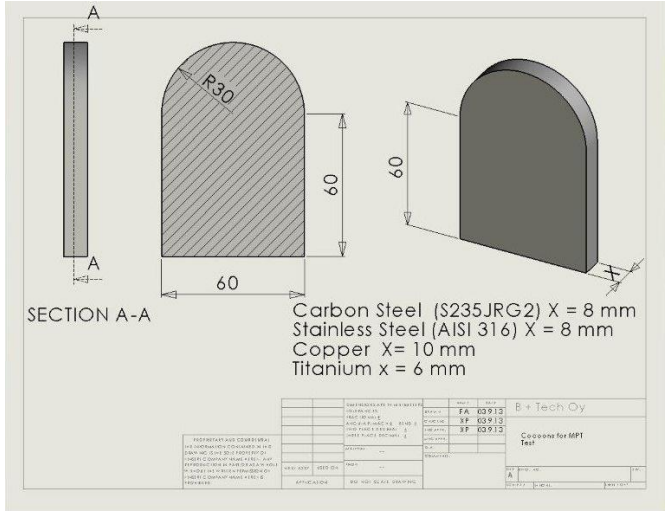
Interaction with metals. Not in ANCHORS:

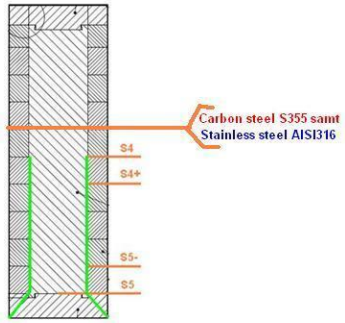
Laboratory tests

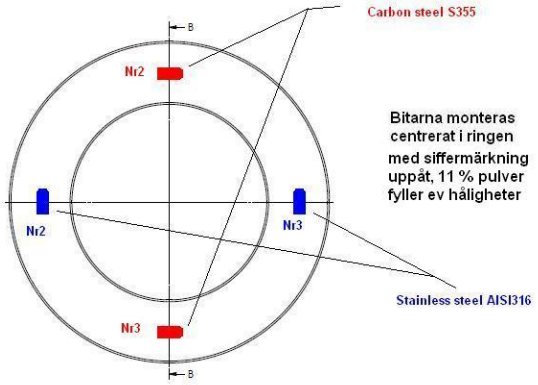


Kumpulainen and Muurien, 2001

Coupons in an “in situ” test. MPT

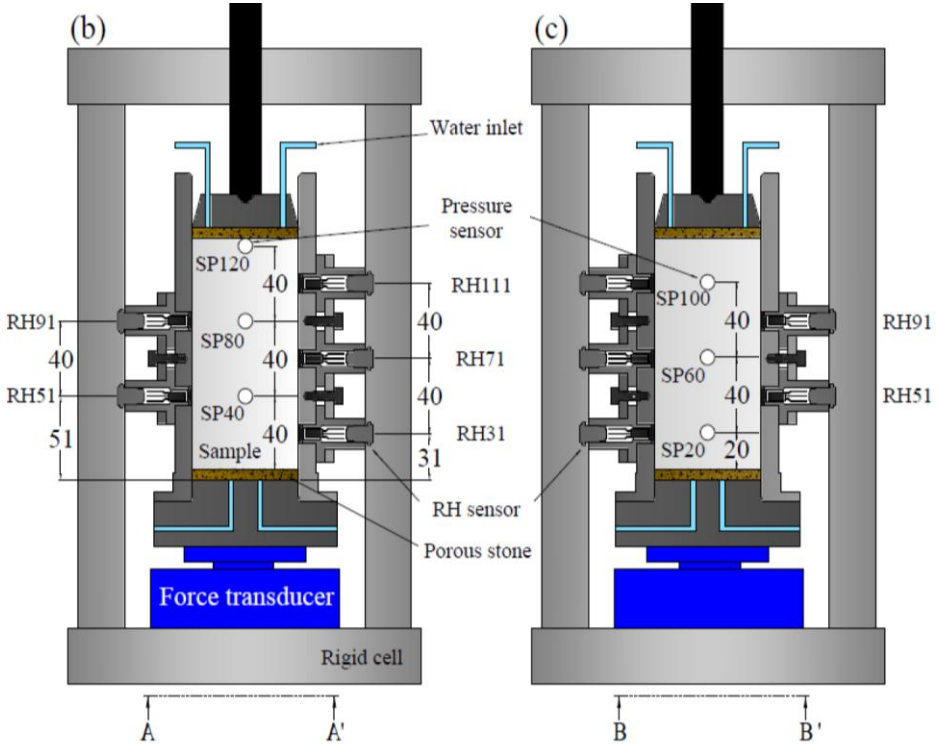






BENTONITE CHARACTERIZATION

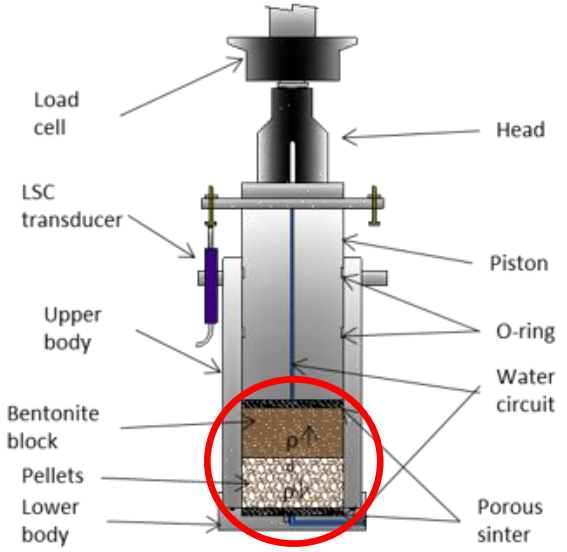
Long tests: Several years. Heterogeneity.



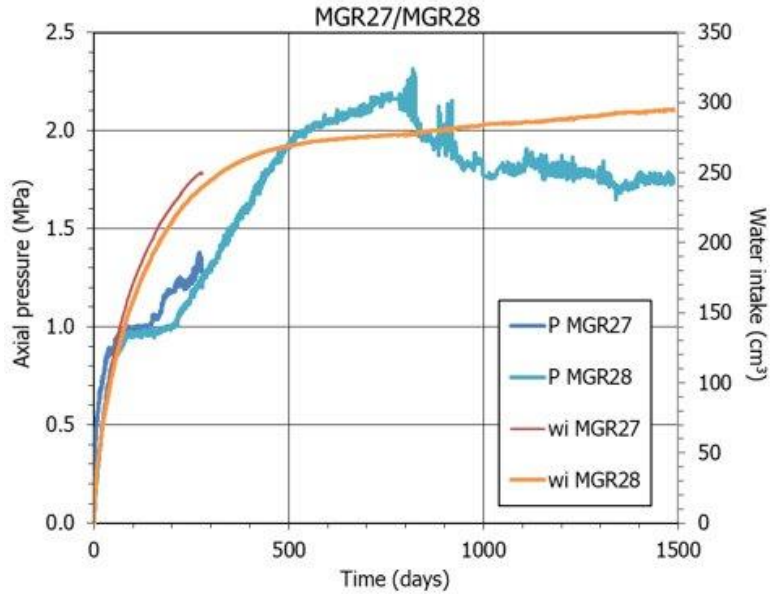
Mock-up 1
(Since October 2015)

Mock-up 2
(Since March 2017)

CNRS-NAVIER



4 years ongoing



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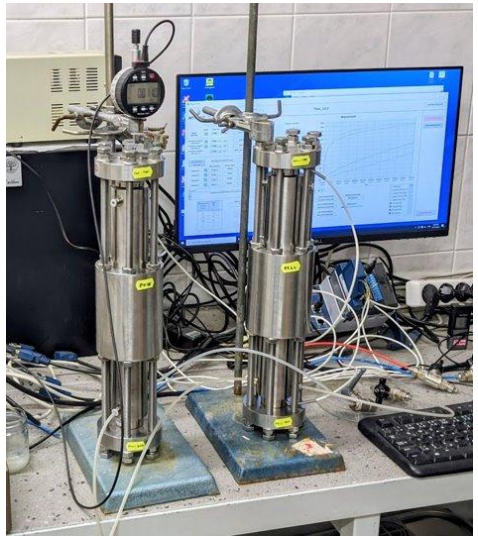
BENTONITE CHARACTERIZATION

Scale effect: Cells to study the friction effect and testing mixtures with large aggregates and different components



CU (cm)

GRS (dm)

VTT (dm)

TUBAF (m)

CONCLUSIONS

- Bentonites are complex materials with different levels of porosity which change during the hydration and the confinement conditions.
- High content of smectite would be the main property.
- Large swelling pressure and low hydraulic conductivity are interesting properties as sealing material.
- The properties change when the water flowing through changes.
- Tests require long periods of time due to the small hydraulic conductivity. Important in quality control tests and in the characterization of new bentonites.
- Even when the sample is saturated, the aggregates continue changing (e.g. basal space).
- The scale effect might be important (e.g. friction effects)
- Repeatability is important. Defining proper standards for bentonite is crucial. Benchmark.

Thank you for your attention!