
HOMOGENISATION OF BENTONITE – LABORATORY TEST RESULTS

Ann Dueck, Lennart Börgesson, Reza Goudarzi

Clay Technology AB

Outline of the presentation

- introduction
- laboratory tests in general
- description of the test types and examples of test results
- available test results

Introduction

- **Buffer homogenisation** has been studied in an SKB project initiated in 2008 to increase the knowledge about the homogenisation processes.
- **Swelling of the buffer blocks and buffer homogenisation are important** functions to meet the requirements on the buffer in a deposition hole after full water saturation.
- It is important to **understand the homogenisation process and be able to predict** the final density distribution of the buffer after swelling and homogenisation, which occurs both during the initial water saturation stage and after possible loss of bentonite caused by for example erosion.

Introduction

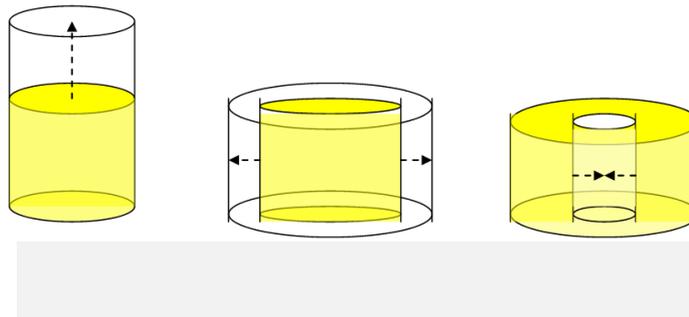
- Important objectives of the project have been to
 - understand the homogenisation - how it evolves and ends,
 - understand how much remaining inhomogeneities may prevail,
 - provide test results that can be used for improvement of hydro-mechanical models and determination of model parameters,
 - provide test results that can be used as case studies for verifications of the models.

Laboratory tests in general

- The laboratory tests made in the project can be divided into four parts:
 - fundamental swelling tests,
 - measurements of friction between bentonite and other surfaces,
 - homogenisation after loss of bentonite in self-healing tests,
 - homogenisation tests in long steel tubes.

Laboratory tests in general

- The fundamental swelling of water saturated bentonite specimens has been studied in different well-defined tests including axial swelling with constant radius, radial outward swelling with constant height, and radial inward swelling into a cylindrical cavity with constant height.



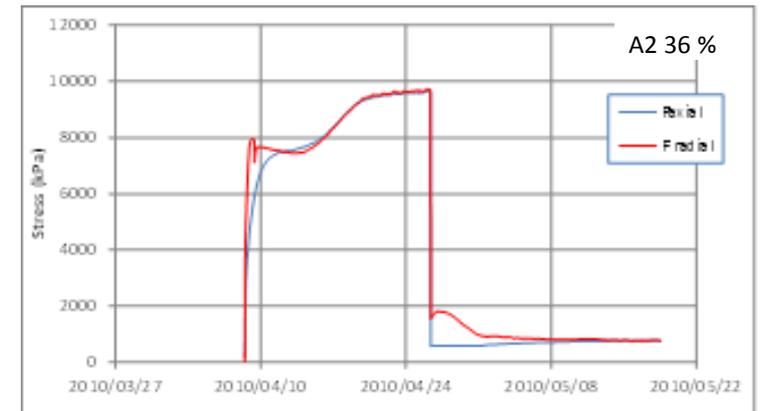
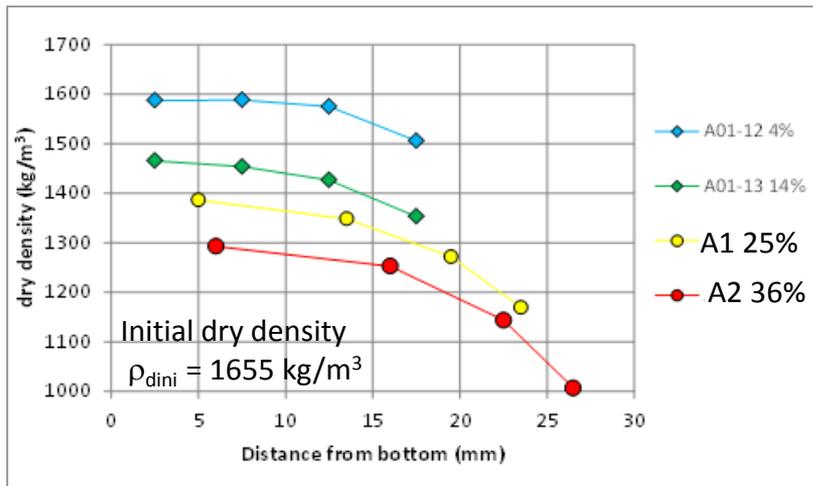
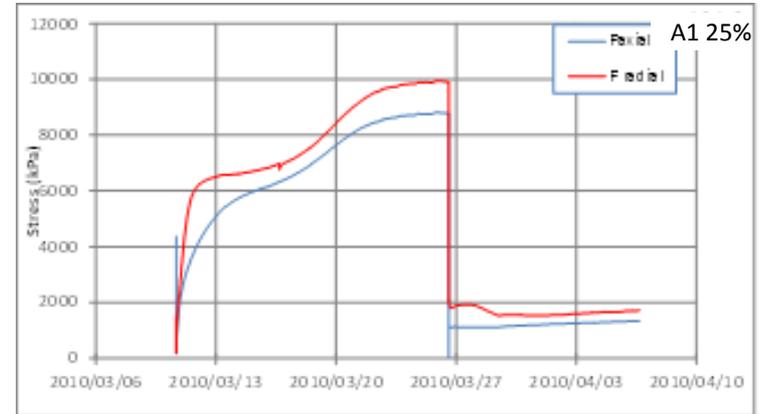
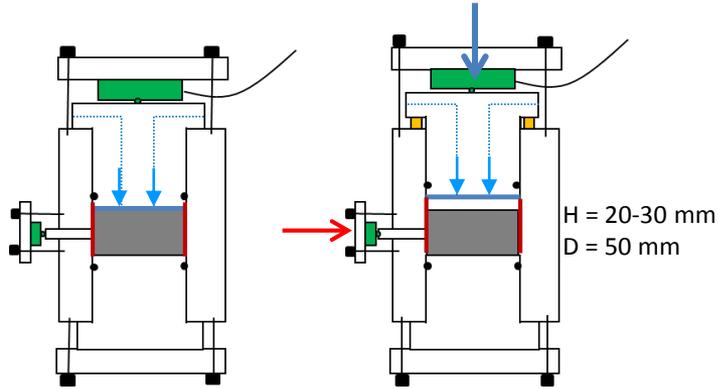
Laboratory tests in general

- In the test series with **loss of bentonite** two medium scale tests have been completed, and in the series with **long steel tubes** one out of ten tests has been completed and dismantled.
- Two different bentonites have been used for the tests but in the main part of the tests MX-80 (Wyoming bentonite from American Colloid Company) has been used.



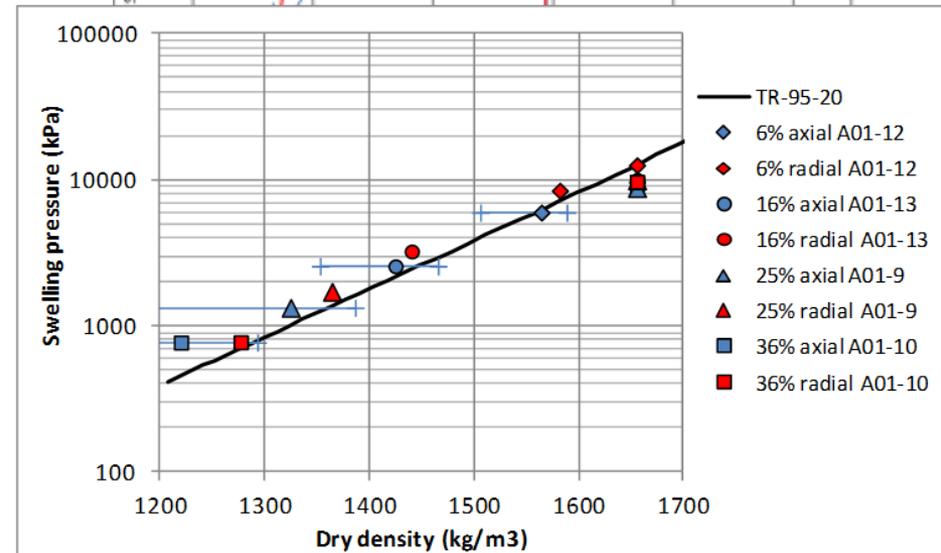
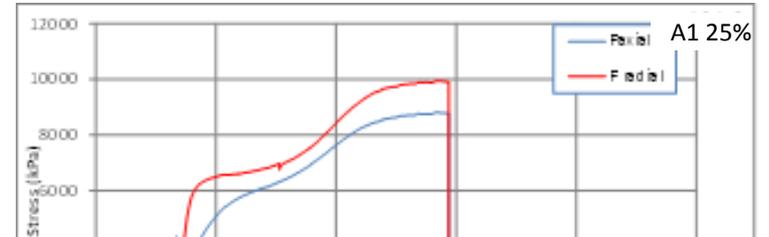
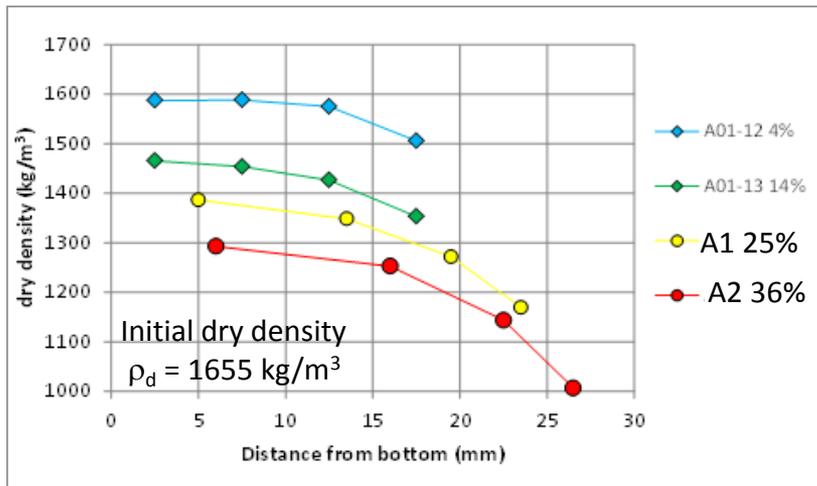
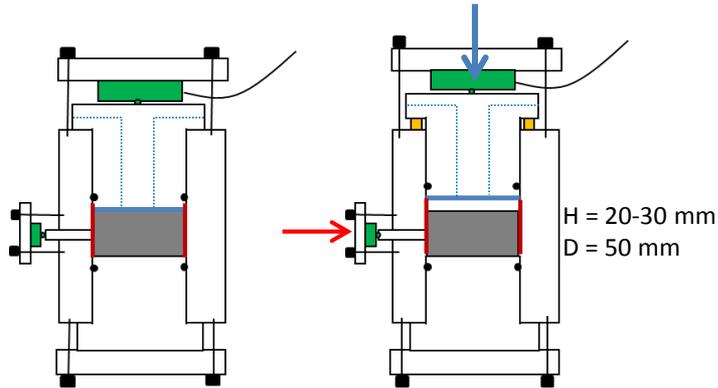
Fundamental swelling tests

Axial swelling



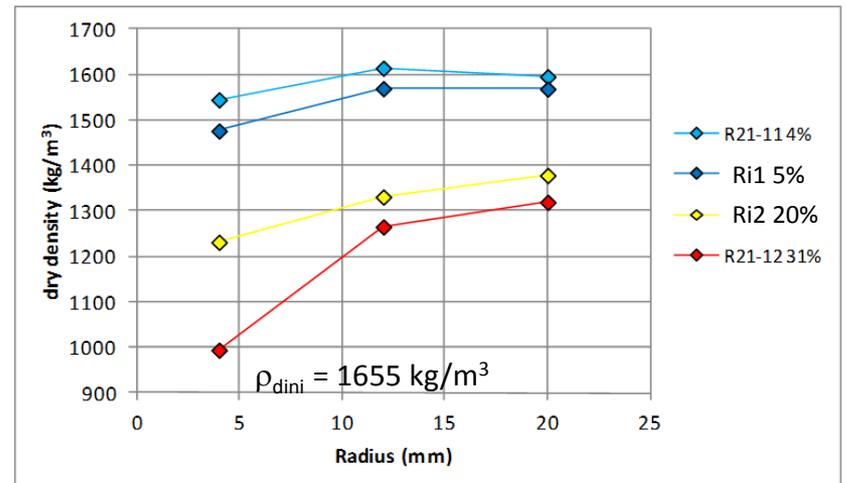
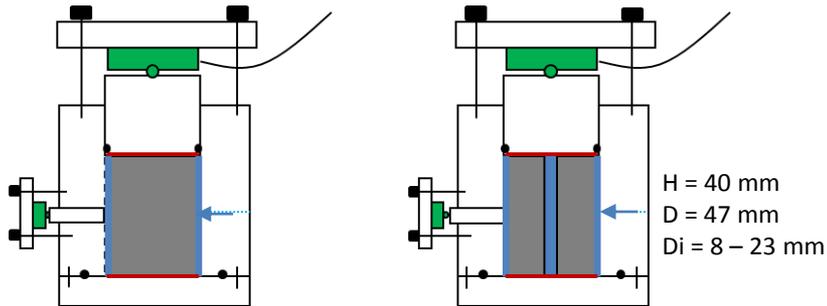
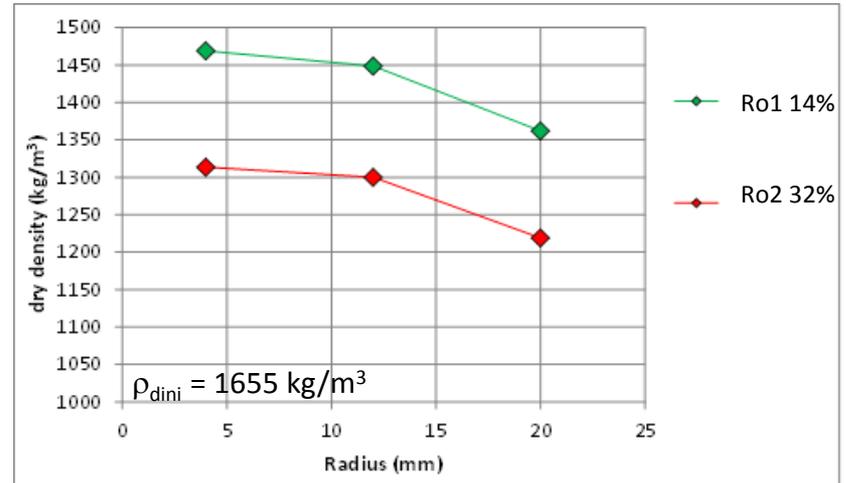
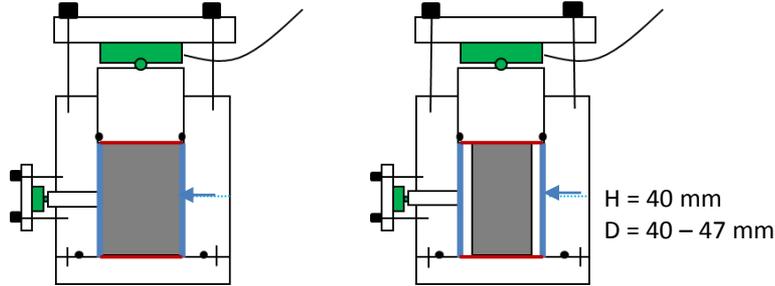
Fundamental swelling tests

Axial swelling



Fundamental swelling tests

Radial swelling

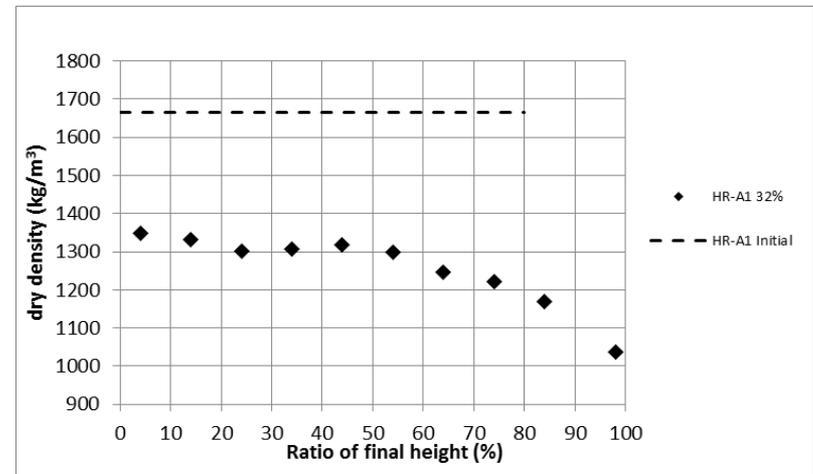
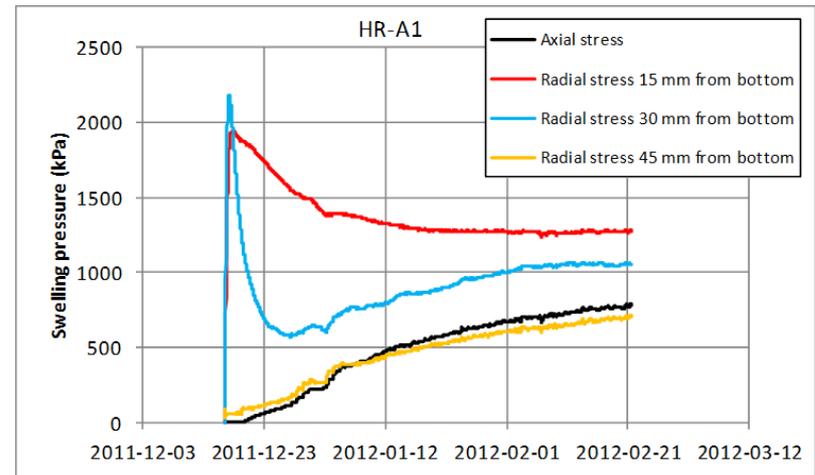
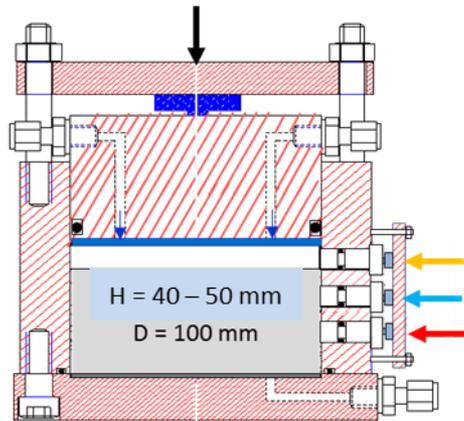


Fundamental swelling tests

Axial swelling

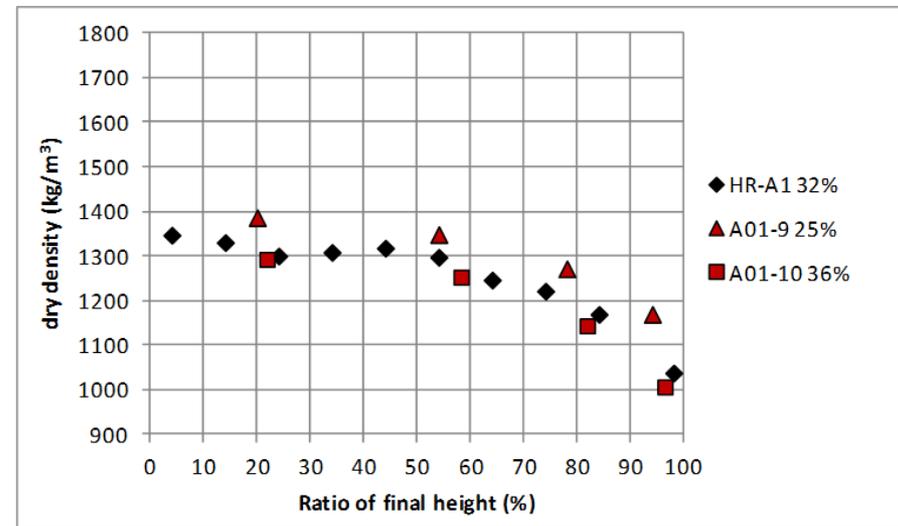
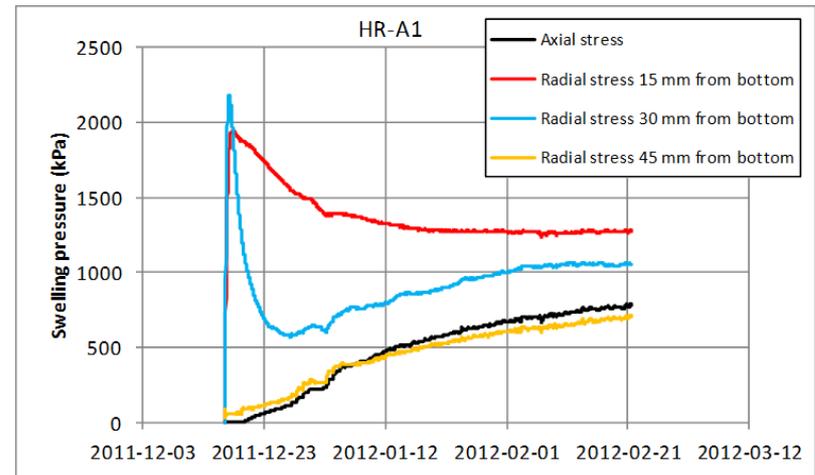
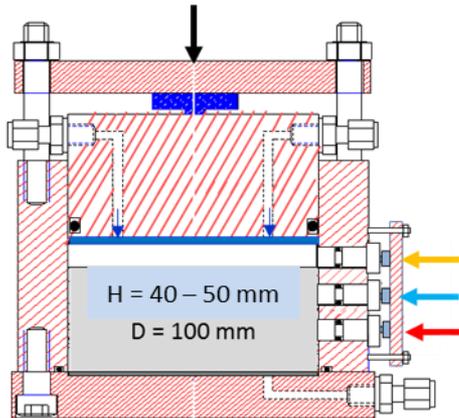
Larger scale – higher resolution

High initial degree of saturation



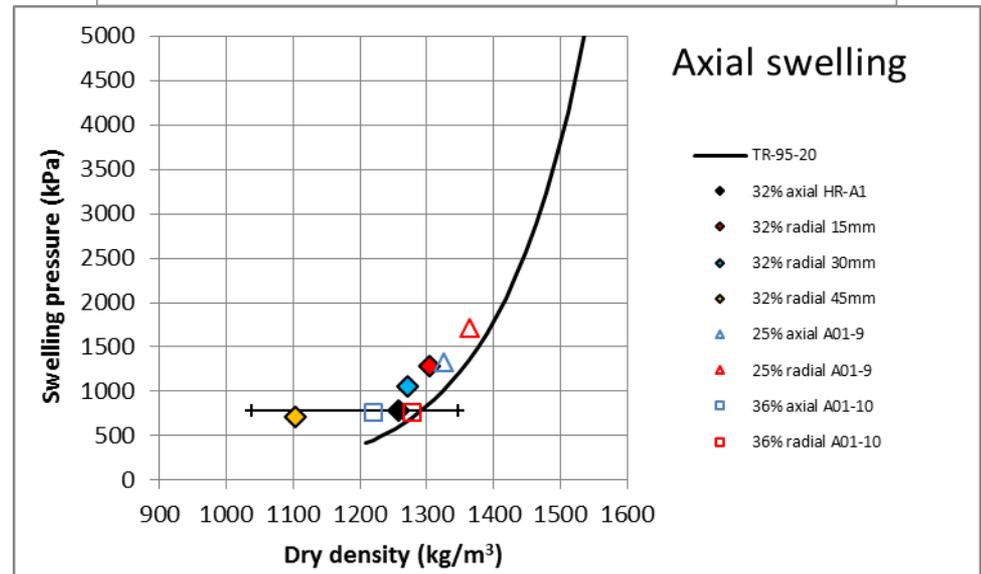
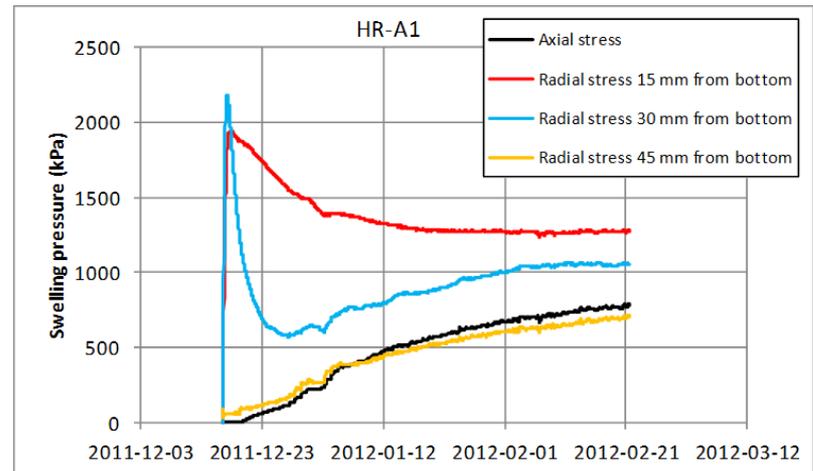
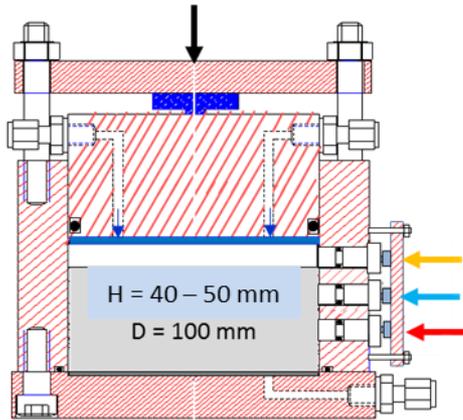
Fundamental swelling tests

Axial swelling



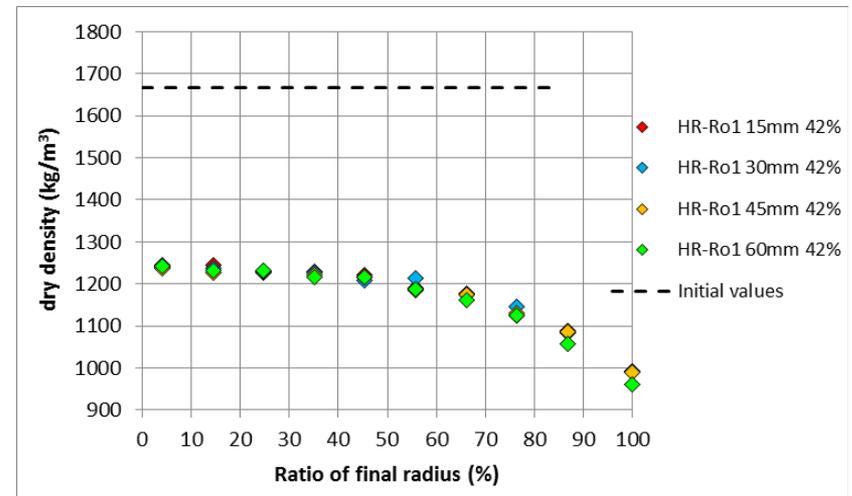
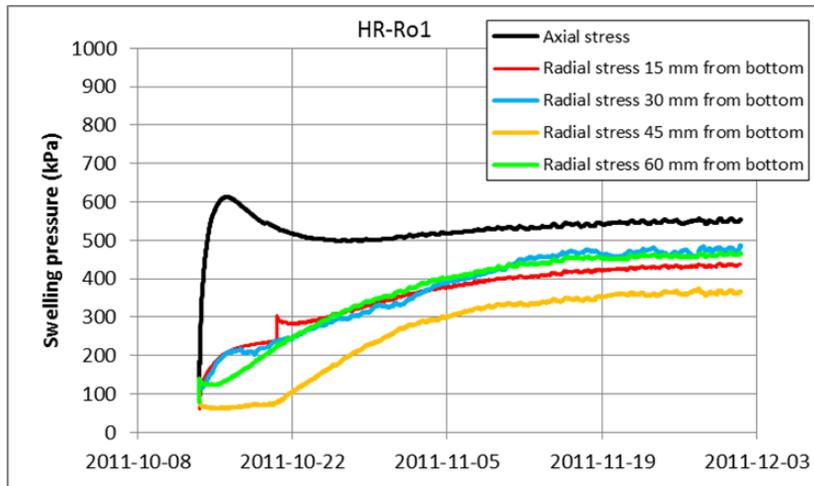
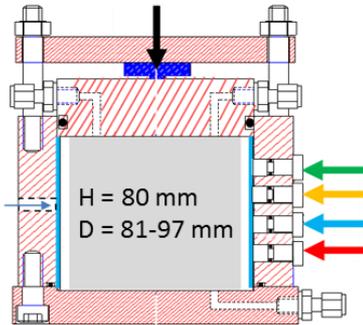
Fundamental swelling tests

Axial swelling



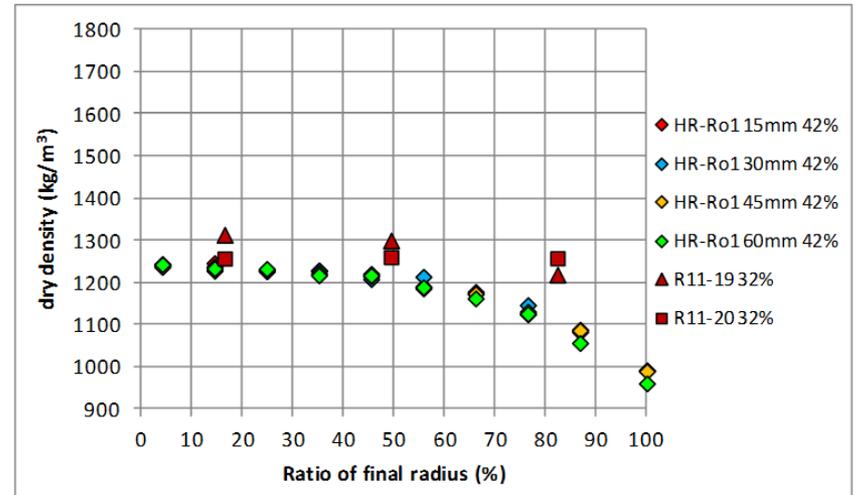
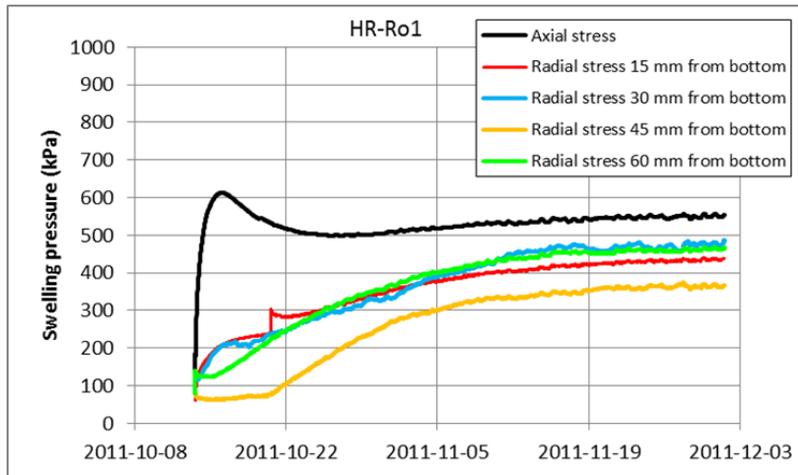
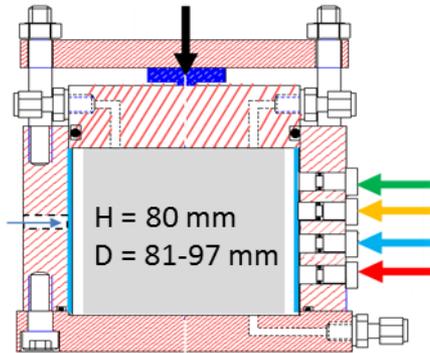
Fundamental swelling tests

Radial outward swelling



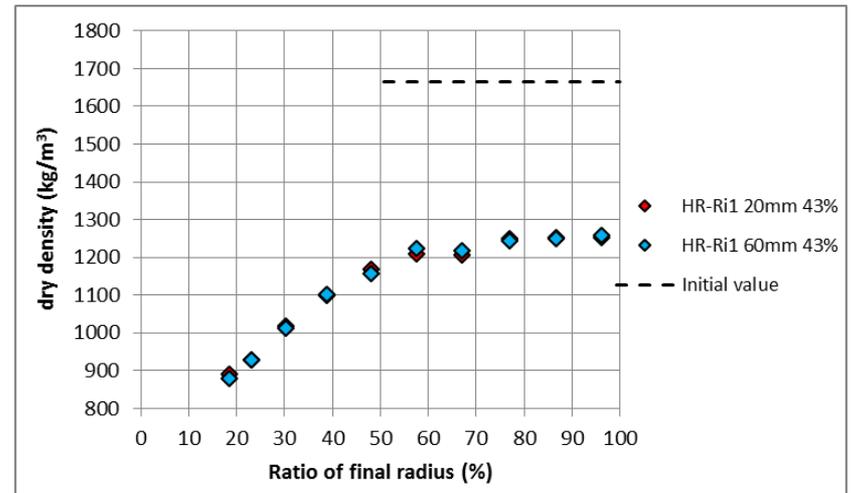
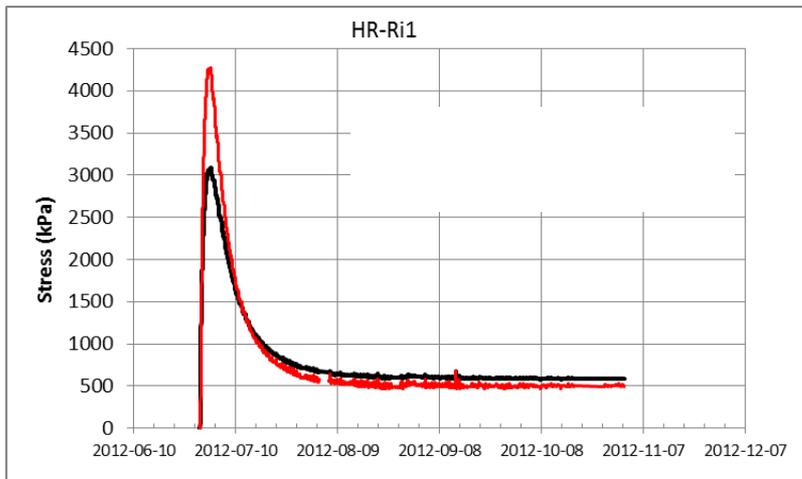
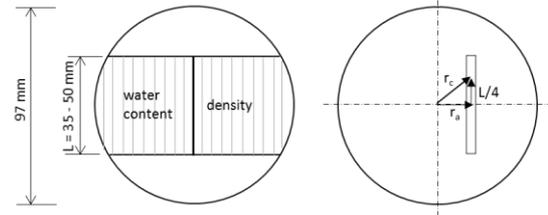
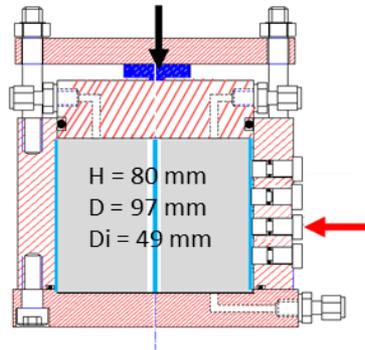
Fundamental swelling tests

Radial outward swelling



Fundamental swelling tests

Radial inward swelling



Fundamental swelling tests

	Material	MX-80		Calcigel		
	Test series	Basic-series	HR-series	Basic-series	HR-series	Total
Type of swelling	Swelling (%)					
Axial	0 - 46	7	4	2	3	16
Radial outward	3 - 45	10	1	2	2	15
Radial inward	3 - 110	6	1	2	1	10
Swelling in all directions	43		1			1

Homogenisation after loss of bentonite in self-healing tests

The self sealing ability of large and irregular cavities in the bentonite is studied with these type of tests.



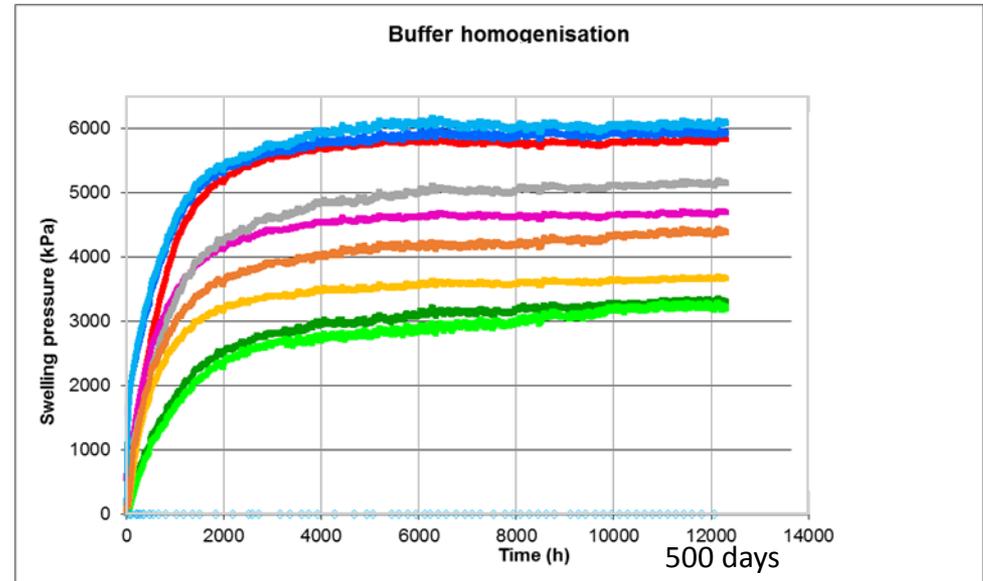
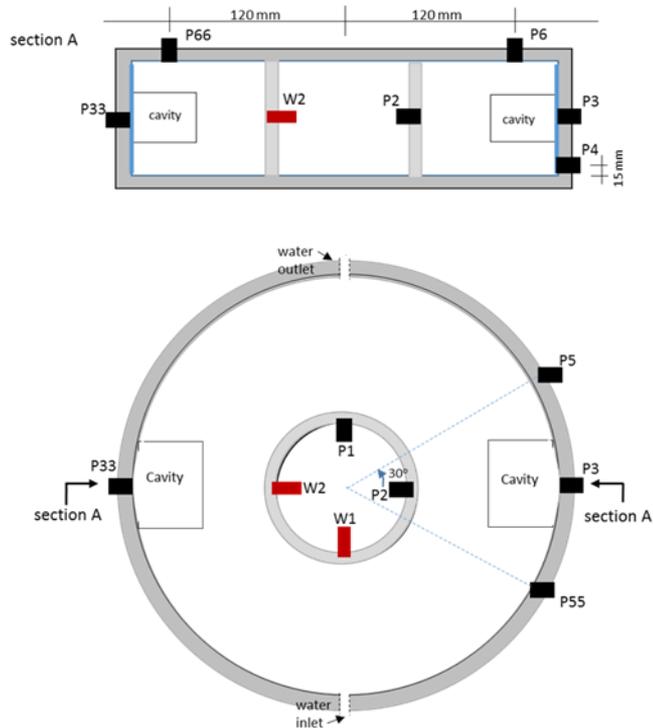
Bentonite ring
 $D_{\text{outer}} = 300 \text{ mm}$
 $D_{\text{inner}} = 100 \text{ mm}$
 $H = 100 \text{ mm}$

Cavities (height*length*depth)
 $35\text{-}50*70*50 \text{ mm}^3$

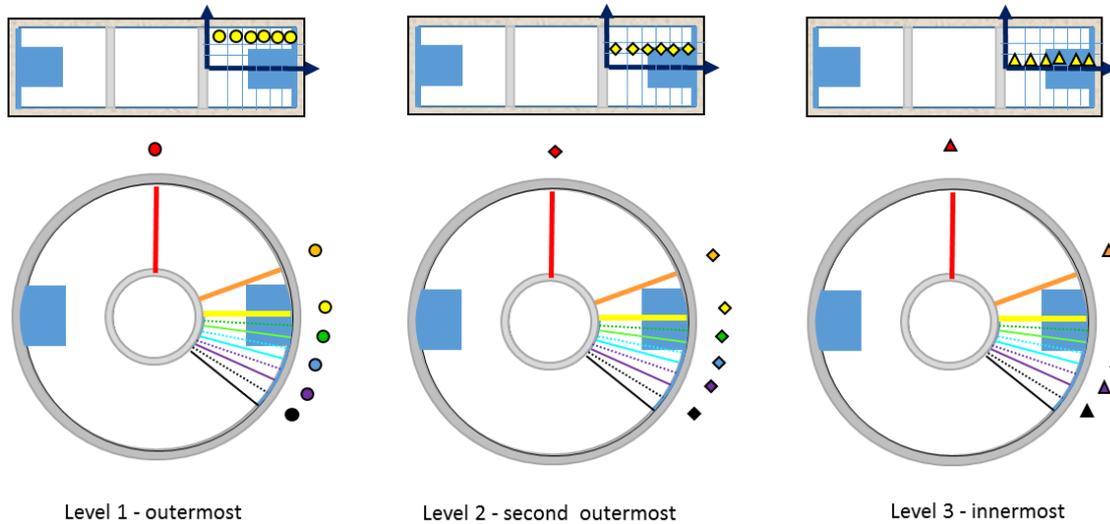
Initial density $\rho_d \approx 1630 \text{ kg/m}^3$

SH tests	Material	Start conditions	Sensors	Test duration
SH1	MX-80	saturated	Yes	33 months
SH2	MX-80	saturated	No	17 months
SH3	Calcigel	saturated	No	ongoing
SH4	MX-80	unsaturated	Yes	ongoing

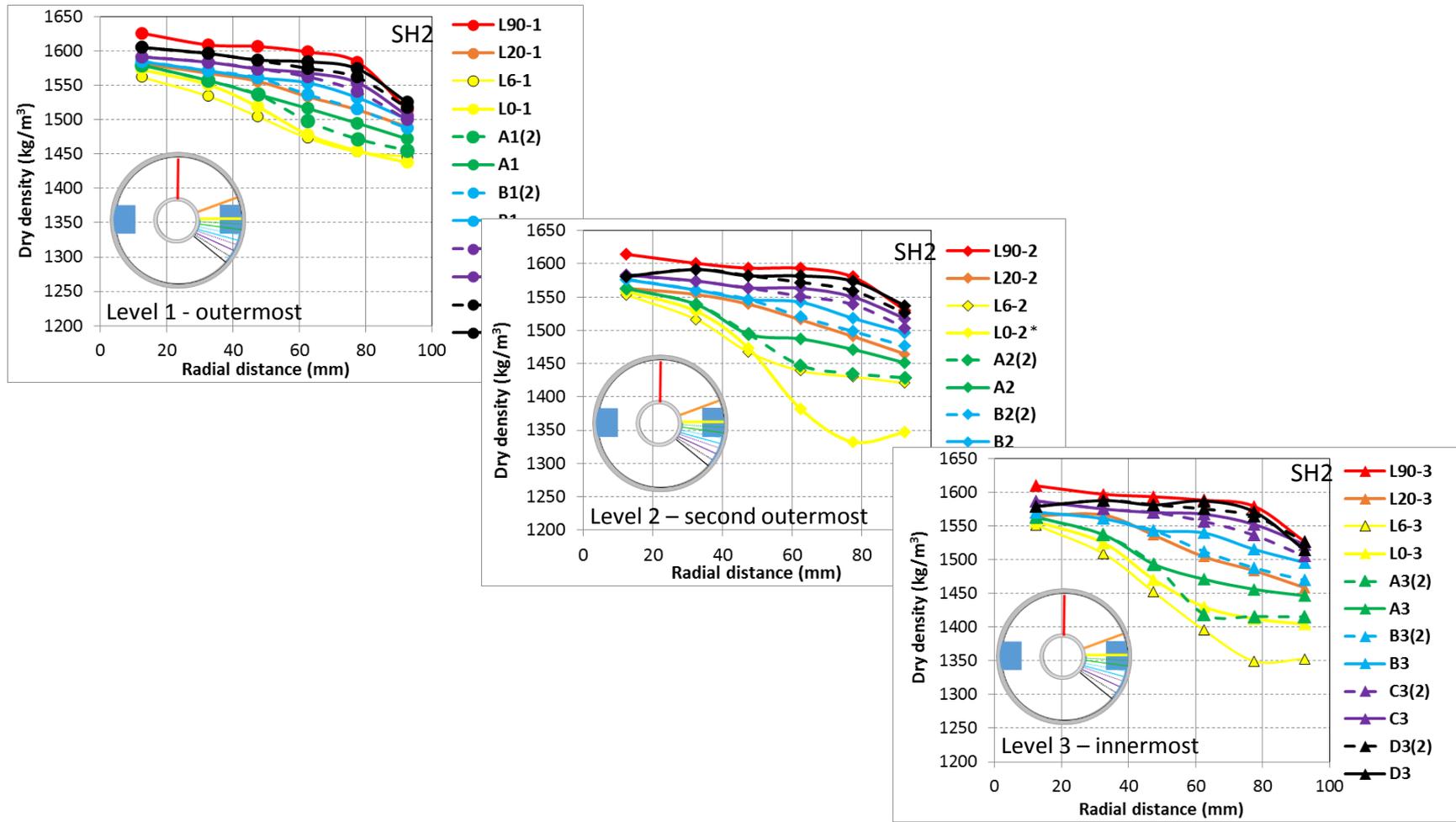
Examples of test results: self healing tests



Homogenisation after loss of bentonite in self-healing tests



Examples of test results: self healing tests



Available test results

Test results from the project Buffer Homogenisation are published in three reports and one additional report is on going.

The data are mainly presented as diagrams or tables in published reports:

- time evolution of stresses at different positions,
- dry density at different positions,
- friction angle at different stress.

Selected test results can be presented in excel-sheets with raw data, i.e. continuous measurements of stresses and distributions of dry density.

(A1, A2, Ro1, Ro2, Ri1, Ri2, HR-A1, HR-Ri1, HR-Ro1, HR-Iso, SH1/SH2)

Final report of the buffer homogenisation project is in preparation where

- laboratory test results will be analyzed,
- findings will be compiled,
- important results will be pointed out,
- analyses from some modelling results will be included.

Further understanding

- the homogenisation – how it evolves and ends,
- how much remaining homogeneities that may prevail,
- what limits the homogenisation.

References

- **Börgesson L, Johannesson L-E, Sandén T, Hernelind J, 1995.** Modelling of the physical behaviour of water saturated clay barriers. Laboratory tests, material models and finite element application. SKB Technical Report TR-95-20. Svensk Kärnbränslehantering AB.
- **Dueck A., Goudarzi R., Börgesson L., 2011.** Buffer homogenisation, status report. SKB Technical Report TR-12-02. Svensk Kärnbränslehantering AB.
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Acknowledgements

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BEACON
Bentonite Mechanical Evolution



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