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MIND

Microbiology In Nuclear waste Disposal

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DELIVERABLE D2.2

Design, set up and operation of experimental equipment

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Publishable Summary

A laboratory scale experiment investigating the impacts of microbial activity on bentonite structure has been started at VTT. The experiment simulates a worst case scenario where bentonite is not compacted, water, gases, nutrients and microorganisms are able to move along easily at temperature hospitable for microbial welfare. The aim is to find out if microorganisms and the produced metabolites are able to change the bentonite structure in favourable conditions and if these changes are significant for the bentonite ability to function in long-term scale. The experiment will be monitored with microbial sampling as well as with atomic force microscopy (AFM) once a year.

NERC (BGS) is responsible for carrying out experiments investigating microbial degradation of bentonite buffers (T2.4) and microbial induced corrosion of canisters (in T2.2). Bespoke vessels have been constructed from grade two titanium, and fitted with 5 load cells (2 axial and 3 radial) for both of these tasks. This apparatus will continuously monitor total stress to see if the microbial activity and corrosion of steel has an effect on the hydromechanical and transport properties of the bentonite. All apparatus components have been manufactured and calibration is now underway. Experiments will begin as planned in Q1 of 2017.

Contents

1 Microbial bentonite long-term storage experiment

VTT has started a laboratory scale experiment investigating the impacts of microbial activity on bentonite structure during spring 2016. This experiment simulates worst case scenario where bentonite is not compacted, water, gases, nutrients and microorganisms are able to move along easily at temperature hospitable for microbial welfare. The aim is to find out if microorganisms and the produced metabolites are able to change the bentonite structure in favourable conditions and if these changes are significant for the bentonite ability to function in long term scale.

1.1 Bentonite storage experiment parameters

The experiment parameters are shown in the Table 1-1. Different waters for the experiment were sampled from Olkiluoto bedrock drillholes and from the Korvensuo reservoir in May 2016. Posiva kindly arranged graphite containing rock from the Olkiluoto bedrock that was crushed for appropriate size (2-6 mm). Bentonite (MX-80, CETCO) used in this experiment was from the same batch that has already been characterised (Kiviranta and Kumpulainen, 2011). The experiment bottles (120 ml) were closed in air with rubber stoppers after addition of bentonite, rock, nutrients and waters (Table 1-1). The bottles are now incubated at 37 °C, still, in the dark. Test bottles are shown in the Figure 1-1.

Table 1-1: Paramenters of the four members of the bentonite storage experiment

Sample	Composition	Amount
Test bottle	Bentonite	5 g
	Olkiluto mixture water*	80 ml
	Olkiluoto rock crush	5 g
	Sterile filtered (0.22µm) nutrients**	
Control 1	Heat treated (180° for 16 h) bentonite	5 g
	Sterile filtered (0.22µm) Olkiluto mixture water*	80 ml
	Autoclaved Olkiluoto rock crush	5 g
	Sterile filtered nutrients**	
Control 2	Bentonite	5 g
	Sterile filtered Olkiluto mixture water*	80 ml
	Olkiluoto rock crush	5 g
	No nutrients	
Control 3	Heat treated (180° for 16 h) bentonite	5 g
	Sterile filtered Olkiluoto mixture water*	80 ml
	Sterile filtered nutrients**	
	No rock	

* Korvensuo water and three different kind of anaerobic groundwaters
** 0.1 mM Na-acetate, 0.1 mM Na-formate and 0.05 mM methanol

1.2 Experiment sampling plan

At the beginning samples for basic chemical analysis and for microbial numbers (microscopy with DAPI (4',6-diamidino-2-phenylindole), DNA extraction and ATP (Adenosine triphosphate)

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measurements from waters used were taken. After a month of incubation a bentonite sample was taken for atomic force microscopy (AFM) to characterise the bentonite at the beginning of the experiment. Samples for microbial and AFM analysis will be taken once a year. In addition the gas composition will be studied with the gas chromatography.

Figure 1-1. Bentonite storage bottles from left to right: Control 1, Control 2 and Test bottle.

2 Microbial degradation of bentonite under realistic pressure conditions

NERC (BGS) is responsible for carrying out experiments investigating microbial degradation of bentonite buffers (T2.4) and microbial induced corrosion of canisters (in T2.2). In order to be able to monitor permeability, total stress, porewater pressure and swelling pressure, both of these experiments will be run in specially constructed vessels designed to hold the samples and allow monitoring of these physical parameters throughout the experiment. The constructed vessels are made from grade two titanium, each fitted with 5 load cells (2 axial and 3 radial) to continuously monitor changes in stress (Fig 2-1). Filters at either end of the sample allow water to be injected and gas/water to be collected.

2.1 Description of Experimental equipment

These systems are housed in dedicated incubators which maintain the correct test temperature (35 ˚C), minimising thermally induced noise in the data. All apparatus components have been manufactured and calibration is now underway. Experiments will begin as planned in Q1 of 2017.

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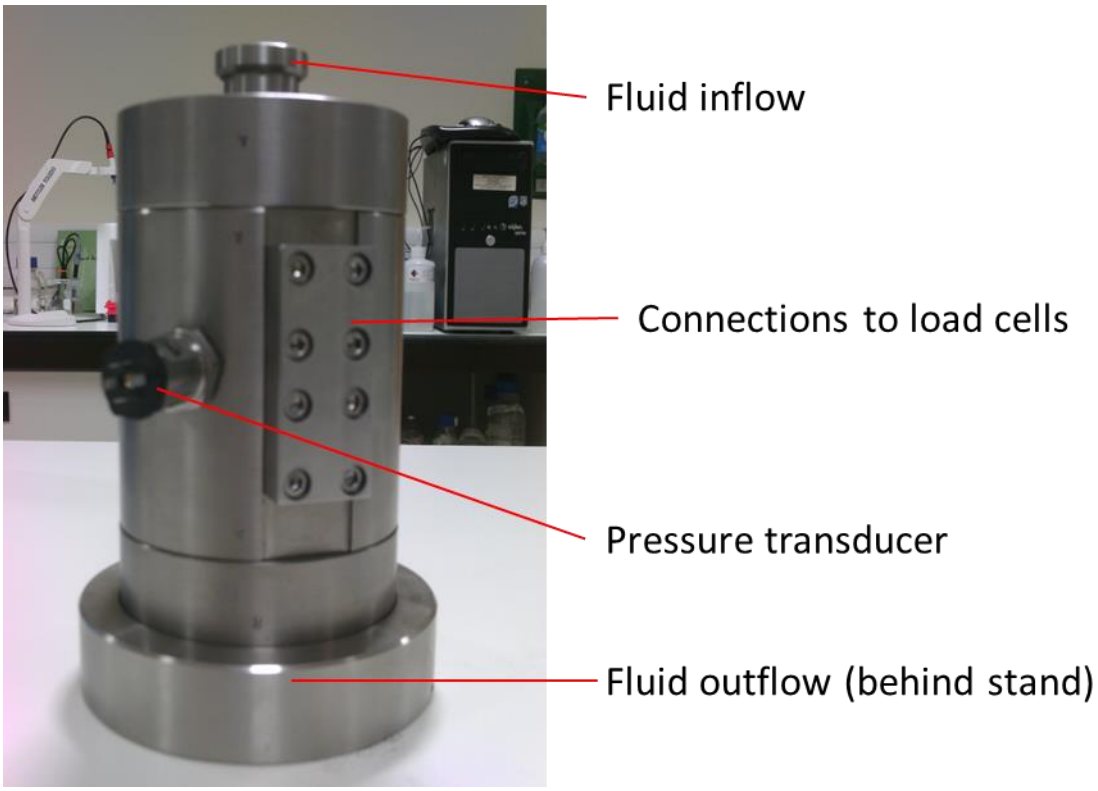

Figure 2-1. Photograph of one of the titanium vessels constructed for this project.

The samples of bentonite (FE bentonite) with embedded unalloyed steel (DH-SE21-14) will be compressed using the sample press shown in Figure 2-2 and inserted into the vessel as shown in Figure 2-3

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Figure 2-2. Press used to compress the samples to the required density.

A typical test will involve initial hydration to determine start swelling pressure, followed by application of hydraulic gradient across the sample to measure permeability and supply ground water to the system. During this time in/out flow will be monitored along with total stress to see if the microbial activity and corrosion of steel has an effect on the hydromechanical and transport properties of the bentonite. Experiments will be run with samples compressed to different dry densities, and with and without microbial inoculation. On completion of experiment microbial characterisation and characterisation of the sample material will be performed.

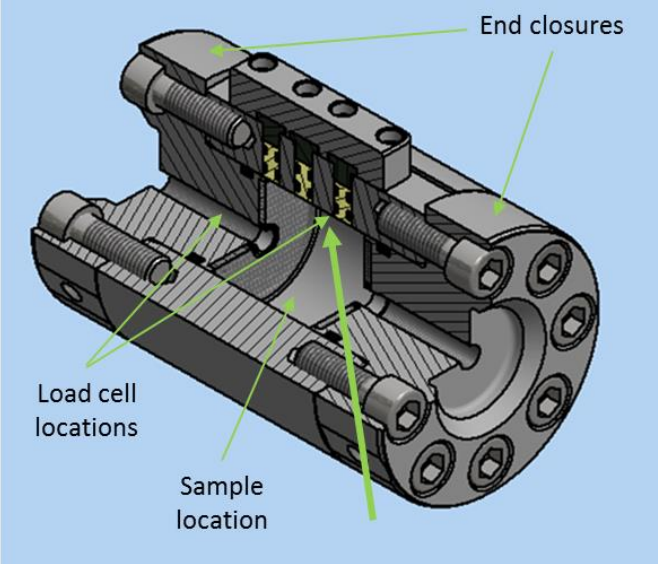

Figure 2-3. diagram showing a cross section of the vessel showing the location of the samples and load cells.

3 Acknowledgement

The MIND-project has received funding from the European Union's Euratom research and training program (Horizon2020) under grant agreement 661880 The MIND-project.

4 References

[1] Kiviranta, L., Kumpulainen, S. 2011. Quality control and characterization of bentonite materials. Working Report 2011-84. (Online) Available at: http://www.posiva.fi/en/databank/working_reports/quality_control_and_characterization_of_bentonite_materials.1874.xhtml?xm_col_type=5&cd_offset=289#.WCXNdFvpjzE

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