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D3.14 EPSP Experiment (DEMONSTRATION)

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ABSTRACT:

The aim of the DOPAS project is to address the design basis of, and reference designs and strategies for, plugs and seals to be used in geological disposal facilities. The Czech experiment "Experimental Pressure and Sealing Plug" (EPSP) is aimed at the study of developments concerning the design basis, reference designs and strategies including compliance issues.

The EPSP plug has been designed as a prototype plug for a future Czech deep geological repository. It is expected therefore that similar plug will function during the whole of the operational phase of the repository, i.e. 150 years with an expected over-pressure of up to 7MPa.

The D3.14 "EPSP experiment (demonstration)" is demonstration action which provides information on successfully installed and running experiment.

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1. CONTENTS

2. INTRODUCTION

The aim of the DOPAS project is to address the design basis of, and reference designs and strategies for, plugs and seals to be used in geological disposal facilities. The Czech experiment “Experimental Pressure and Sealing Plug” (EPSP) is aimed at the study of developments concerning the design basis, reference designs and strategies including compliance issues.

The EPSP plug has been designed as a prototype plug for a future Czech deep geological repository. It is expected therefore that similar plug will function during the whole of the operational phase of the repository, i.e. 150 years with an expected over-pressure of up to 7MPa.

Furthermore, the plug has been designed as a multilayer system consisting of two main structural elements which ensure the overall stability of the system, i.e. concrete blocks and a sealing element - a bentonite section positioned between the concrete blocks. Fibre shotcrete was used in the construction of the various elements of the EPSP; the bentonite sealing section was constructed by means of compaction and spray technology.

The plug will be tested by means of injecting air/water/a suspension into a pressurizing chamber followed by the monitoring of the performance of the plug. As a result of the geological conditions within the EPSP experimental drift at the Josef underground laboratory, it was necessary to use grouting so as to lower the permeability of the rock mass prior to the commencement of the EPSP plug experiment.

The D3.14 “EPSP experiment (demonstration)” is demonstration action which provides information on successfully installed and running experiment.

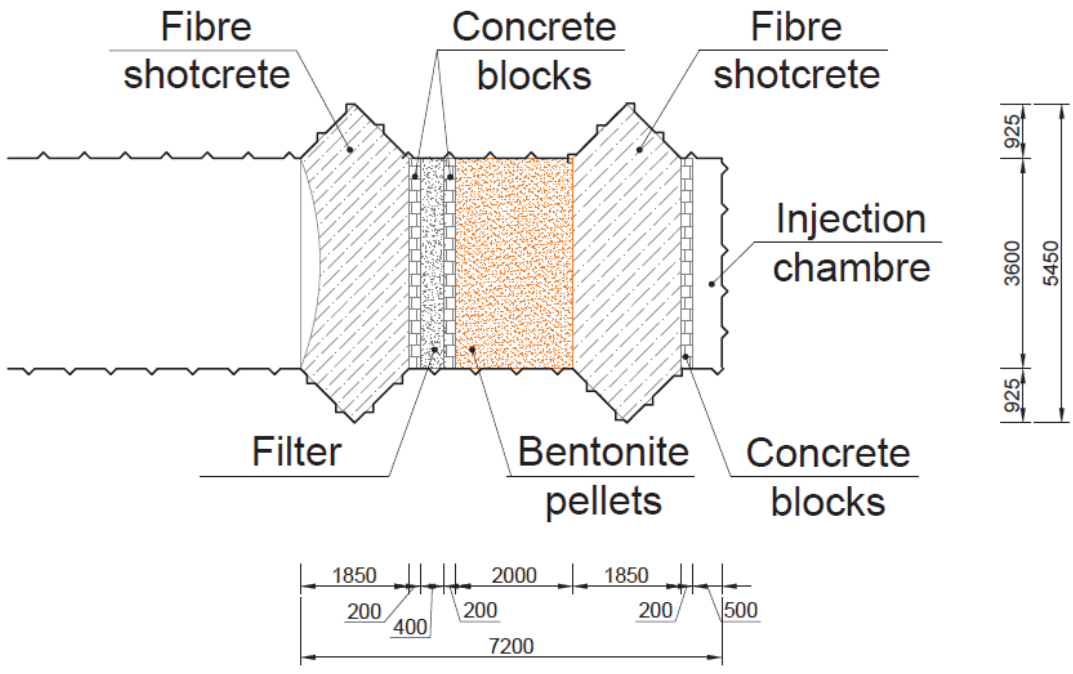

Figure 1 - Scheme of EPSP

2.1. **EPSP**

EPSP is not a specific DGR plug or seal; rather it was built at a similar scale to a disposal tunnel plug and will contribute specifically towards the development of a reference design for such structures. The objective of the EPSP experiment is to test both the materials and technology to be used for implementation, not to test the design and performance of the reference disposal tunnel plug. At this early stage in the Czech geological disposal programme (SÚRAO 2011), more than 50 years prior to the scheduled commencement of operation, it is considered by those involved more important to build knowledge and experience rather than to refine implementation designs for an, as yet, unidentified site with unknown mechanical, hydrogeological and chemical characteristics.

The EPSP experiment is the first time that SÚRAO has carried out detailed work on plugs and seals. The conceptual design for EPSP experiment includes the following components (see DOPAS deliverable D2.1):

- Pressure Chamber: The pressure chamber (or injection chamber) is an open area that can be used to pressurise the inner concrete plug. The chamber contains an inlet valve and a drain valve that can be used to fill the chamber with air (gas), water or bentonite slurry. The chamber is as small as possible so as to allow the pressure to be readily controlled. The pressure chamber is sealed with a waterproofing finish.

  The chamber preparation was finished in October 2014

- Concrete Walls: Concrete walls (made of blocks) were used to facilitate the construction of EPSP. Three concrete walls were built: one between the pressure chamber and the inner concrete plug, one between the bentonite and the filter, and one between the filter and the outer concrete plug.

  The separation wall between the chamber and inner plug was ready on November 5th 2014. The filter containing walls were completed in June 2015.

- Inner Concrete Plug: The inner concrete plug forms one of the sealing components of EPSP and was constructed using sprayed glass-fibre concrete. The fibre concrete is of relatively low pH.

  The inner plug was erected on December 12th-13th 2014.

- Bentonite Pellets: The bentonite pellet zone comprises B75 bentonite, i.e. a natural and high-smectite content Ca-Mg bentonite with notably high iron content in the octahedral layer of the smectite. The purpose of the bentonite is to seal and absorb/adsorb any water that leaks across the inner concrete plug. The bentonite zone is 2m long.

  The bentonite sealing was emplacen on June 5th-15th 2015.

- Filter: The filter will collect any water that is not absorbed by the bentonite. This is most likely to occur if the leakage rate across the inner concrete plug is sufficient for piping and erosion of the bentonite to occur. The filter may also be used to reverse the direction of pressurisation of EPSP.

The filter erection was completed at same time as bentonite sealing emplacement in June 2015.

- Outer Concrete Plug: The outer concrete plug is designed to hold the other components of EPSP in place. However, should the direction of pressurisation of EPSP be reversed, the outer concrete plug will have to perform as well as the inner concrete plug, and, therefore, the requirements on the outer concrete plug are the same as the requirements on the inner concrete plug. The outer plug was built in same manner as inner plug and is identical to it.

  The outer plug was erected on June 19th-20th 2015.

2.2. **LOCATION OF EPSP**

The EPSP experiment is being built at the Josef underground laboratory. The EPSP experimental plug itself is located in the M-SCH-Z/SP-59 niche. The measurement system technology and the data loggers are located in the M-SCH-Z/SP-55 niche.

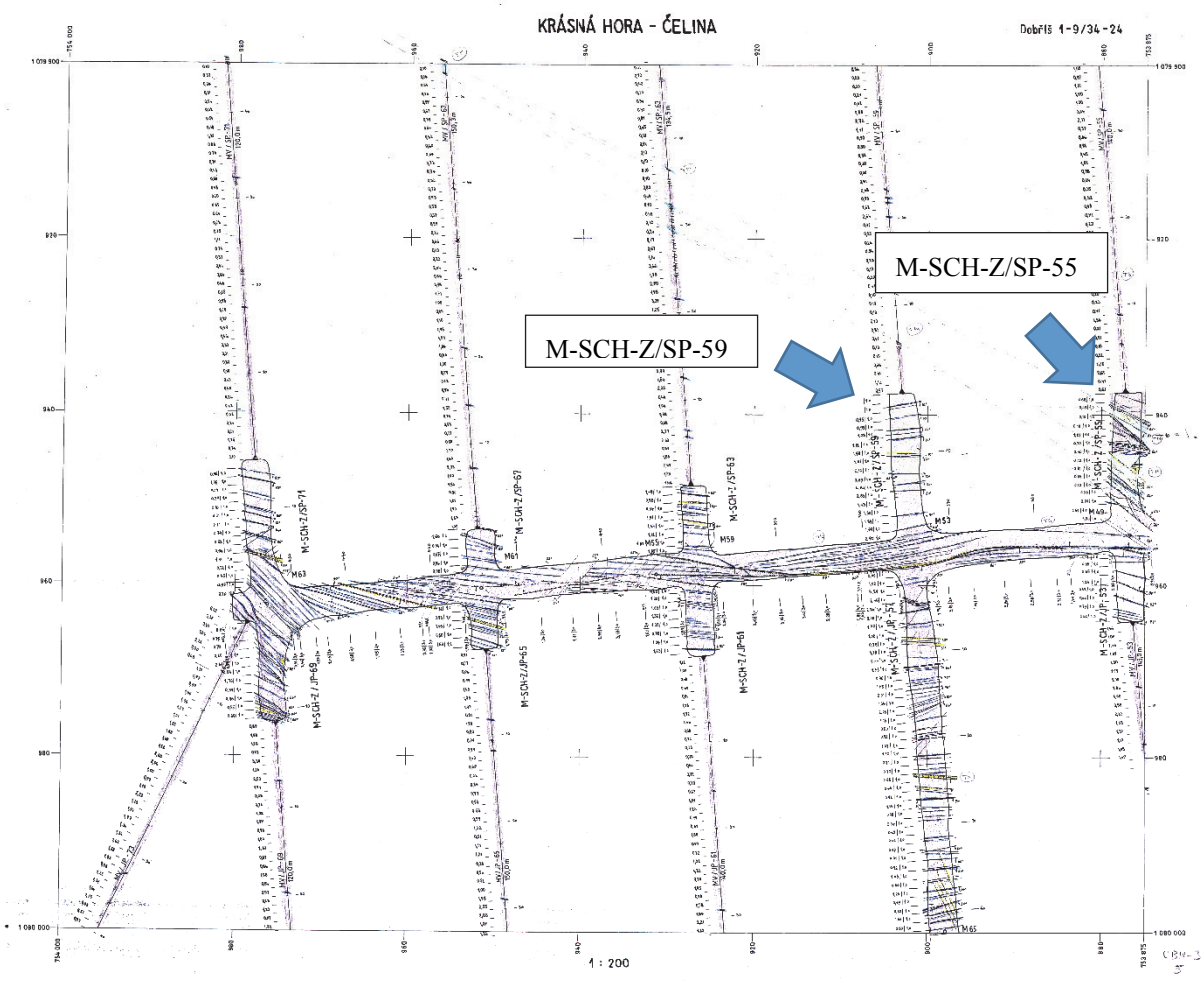

Figure 2 - EPSP location

3. INSTALLATION OF EXPERIMENT

The EPSP experiment was installed in following steps:

1 Preparation of the pressurisation chamber <2 m^3 (including installation of pressurisation tubing).

2 Treatment of the pressurisation chamber with waterproofing.

3 Installation of the first concrete separation wall between the pressurisation chamber and the inner plug.

4 Installation of the inner plug using glass fibre low-pH shotcrete.

5 Installation of sealing core, filter and auxiliary structures (concurrent process):

   a. Emplacement of the bentonite sealing material.

   b. Installation of the second concrete separation wall between the bentonite and the filter.

   c. Installation of the filter material.

   d. Installation of the third concrete separation wall between the filter and the outer plug.

6 Installation of the outer plug using the same material used for the inner plug.

The installation of the plug, from installation of the first concrete separation wall to installation of the outer concrete plug, took about 3 months. This does not include the time required for grouting, and monitoring technology. The total time from chamber adjustment to fully operation experiment was 10 months. A major delay was caused by contact grouting of inner plug where several campaigns were done with long waiting time for curing in between. The shotcreting action (plug erection) by itself was very fast. It took less than 24h to erect each plug followed by 1 month curing.

Monitoring instrumentation was installed gradually as construction progresses.

The EPSP experiment construction works have been successfully finished on July 20th 2015. Functionality has been demonstrated by series of tests. From July 21st the experiment has entered the experimental phase.

For more detail information about experiment installation see D3.20 EPSP plug test installation report.

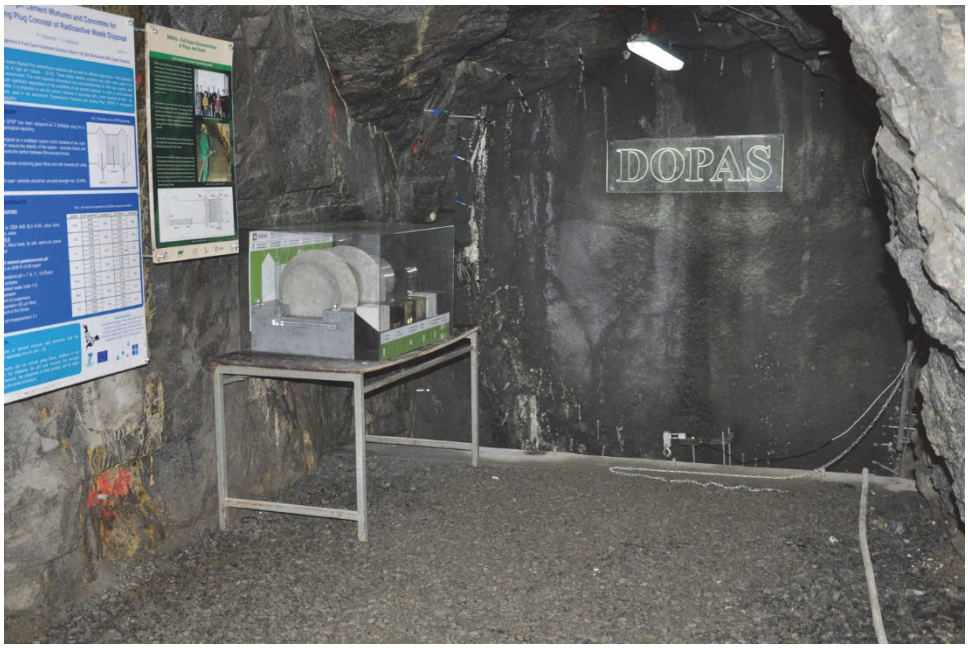

Figure 3 - Installed EPSP experiment

Figure 4 - Low pressure and high pressure pump of EPSP

4. RUN OF THE EXPERIMENT

An experimental testing of EPSP started during the construction process. The inner plug was pressurised through injection of water and air into the injection chamber up to 0.5 MPa to check the water tightness of the concrete and to determine if grouting was needed.

Once the outer plug had cured, the main experimental programme started with a series of short water injection tests followed by long-term tests at various pressure levels (starting at 0.1 MPa going gradually to up to 1 MPa). At 1 MPa a possible channelling of the bentonite seal was detected. At this time, the swelling pressure in the bentonite had not yet fully developed.

In order to avoid erosion of the bentonite, the testing sequence was interrupted and the sealing section was saturated by injection of water in both the filter and the pressurisation chamber to allow swelling pressure to develop. Saturation started at low pressure and was gradually increased to just over 1 MPa.

Following the saturation of the bentonite, a short pressure test was undertaken involving injection of bentonite slurry into the pressurisation chamber at pressures up to 2.5 MPa. The pressurisation chamber was then cleaned up, and pressurisation of the experiment using water pumped into the pressurisation chamber resumed.

For experimental data and results, see D4.6 Monitoring data from EPSP plug test summary report.

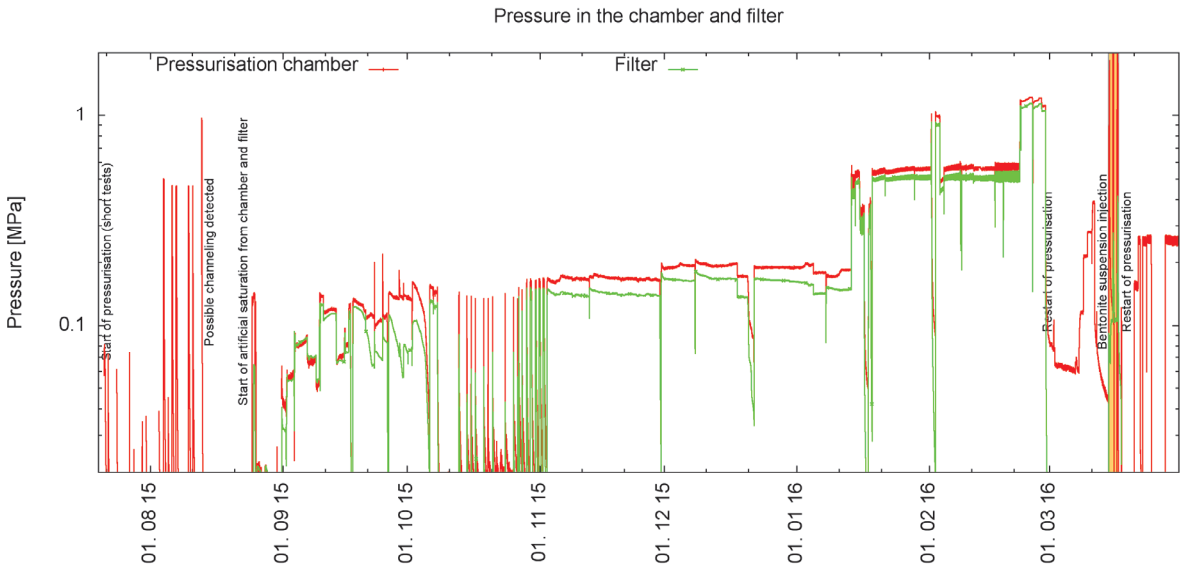

Figure 5 - EPSP pressurisation sequence

5. CONCLUSION

The EPSP experiment has been successfully erected. During erection the technologies and materials for DGR plugs have been tested. The construction works itself finished on July 20th 2015 and basic functionality has been demonstrated by series of tests.

From July 21st the experiment has entered the experimental phase during which extensive testing of EPSP plug is being carried out.