PEBS Newsletter No. 5

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This newsletter informs about the in-situ activities of BGR within the framework of PEBS.

Understanding and modelling THM-C processes and their evolution in the engineered barrier system (EBS) of geological repositories for radioactive waste at different stages under in-situ as well as under laboratory conditions is one of the main targets of PEBS. BGR`s contribution to WP2 consists of two geophysical in-situ experiments. The heater experiment (HE-E) deals with the EBS behaviour immediately after repository closure, whereas in the engineered barrier experiment (EB) the main focus lies on the resaturation phase of the EBS. Both experiments are performed at the Mont Terri Rock Laboratory within the shaly facies of Opalinus Clay (OPA).

HE-E experiment

The HE-E experiment (Gaus, I. et al., 2011) is a 1:2 scale heating experiment set up in a 50 m long micro-tunnel with a diameter of 1.3 m. Two different types of buffer material are used: pure bentonite (MX 80) and a sand-bentonite mixture (SB, 65/35). The maximum temperature at the heater surface will be reached at 140 °C. In the early post-closure phase the maximum temperature pulse is expected in the largely unsaturated buffer material.

The development of the SB and the neighbouring rock is monitored with the help of a small seismic array consisting of 5 piezoelectric transducers serving as emitters and 10 transducers that serve as receivers. The installation and maintenance are carried out by GMuG (Figure 1).

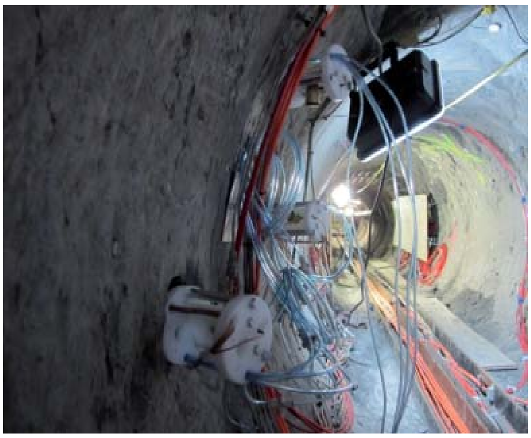

Figure 1. Three piezoelectric transducers just after installation close to the tunnel wall. These were covered later by the sand-bentonite mixture.

Daily automatic measurements are performed between 3 parallel boreholes at distances of 26 cm, 33 cm and 48 cm and along multiple paths in the SB. In total, 50 different travel paths are used and seismic travel paths with the orientations parallel to, naormal to, and at a 45° angle to the bedding planes are realised. The recording started on March 12th, 2011 (day 1). Figure 2 shows the seismic traces recorded in the OPA at a distance of 10 cm from the interface OPA/SB within the first 300 days of recording (until January 5th, 2012). Some recordings are defective, for example around day 30.

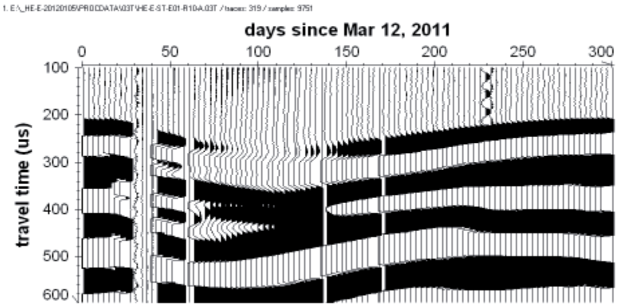

Figure 2. Seismic section recorded in the OPA at 10 cm distance from the interface OPA/SB. Only every third trace is plotted.

The P-wave arrivals can be identified very clearly at around 200 µs (day 1). The pronounced variation of these first arrival phases with time is a clear indication of changes in the mechanical properties of the OPA along the travel path. The appropriate derived and normalised seismic P-wave velocities (v_p) are plotted in Figure 3. Furthermore, derived velocities for distances of 20 cm and 30 cm from the interface OPA/SB are plotted.

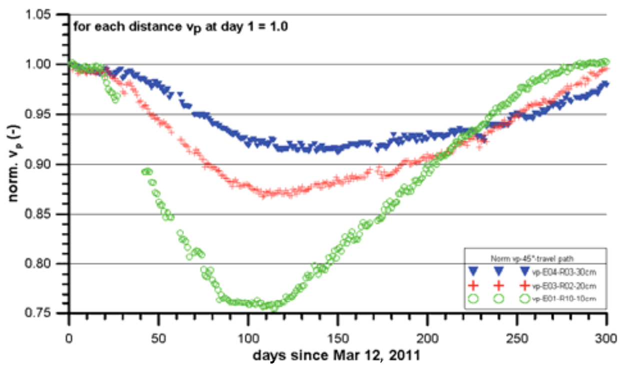

Figure 3. Normalised seismic P-wave velocities in the OPA at distances of 10 cm (green), 20 cm (red) and 30 cm (blue) from the interface OPA/SB.

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Around day 25 the travel times start to increase (v_p drops) and the amplitudes drop. During that time the installation work and the filling of bentonite in the rear section of the tunnel started. The intensified ventilation during that work phase and the later emplacement of the SB material led to the remarkable drop in v_p in the OPA. The desaturation process very likely results in microcracks, which are responsible for the reduced v_p in the OPA. The test section was closed on day 53. The heater elements were installed between days 80 and 86 and were switched on on day 109. From day 130 on, the amplitudes start to become stronger and v_p increases. This can be caused by a gradual closing of the microcracks and/or a pore water pressure builtup. Around day 300, travel times and amplitudes are very close to the starting situation.
Comparing the 3 v_p graphs in Figure 3 it is obvious that the rock material closer to the interface OPA/SB (10 cm) is more affecterd by microcrack creation than material at greater distances (20 cm and 30 cm). It is worth noting that after 300 days only the v_p at 10 cm distance reach the initial value.

In the SB material a more or less continued increase in amplitudes and a decrease in travel times can be observed, which indicates a gradual consolidation of the SB material (Figure 4).

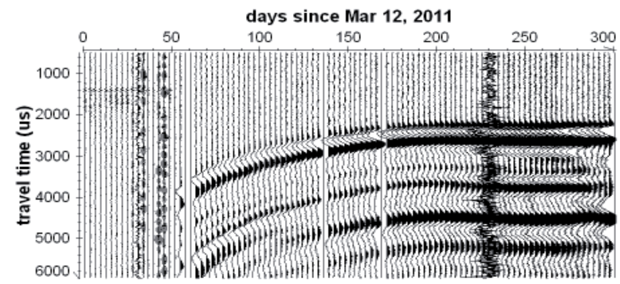

Figure 4. Seismic section recorded in the SB material between 5 cm and 10 cm from the interface SB/OPA. Only every third trace is plotted.

Overall the experiment is proceeding very well and the monitoring continues.

EB experiment

The PEBS activities in the EB experiment are a continuation of work started in 2001 (Mayor, J.C. et al., 2007). The EB experiment aimed to demonstrate a new concept for the construction of HLW repositories in horizontal drifts. BGR conducted an initial geophysical characterisation of the EB niche and performed seismic transmission measurements between 4 boreholes with 24 piezoelectric transducers over 576 days during the saturation phase of the backfill material (bentonite from Serrata de Nijar, Spain).These seismic transmission measurements are due to resume in autumn 2012, just before the dismantling. To access the current stage of the bentonite BGR drilled two boreholes into the EBS in autumn 2011 (Figure 5).

Figure 5. Drilling through the 2.2 m thick concrete plug into the bentonite for core sample extraction.

Core samples were taken for laboratory investigations at the rock laboratories of the partners AITEMIN and GOLDER. Furthermore one borehole was used for ultrasonic interval velocity and geoelectric measurements. For the geoelectric measurements, a BGR probe with 50 electrodes spaced at intervals of 1.6 cm was used. Several Wenner surveys were conducted. A result of a finite element inversion of the section measured close to the concrete plug is shown in Figure 6.

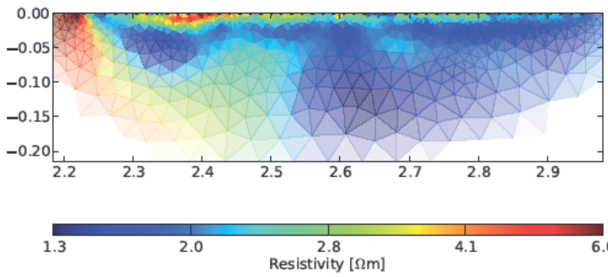

Figure 6. Electrical resistivities derived from geoelectrical measurements in the bentonite. Y-axis: depth of penetration (m).

Higher resistivities are measured close to the interface plug/bentonite at 2.2 m. The very thin layer with higher resistivities is worth mentioning; this is most probably caused by drilling. Beyond 2.8 m the material seems to be homogeneous with resistivities around 2 Ωm.

Content of the next Newsletter

The following Newsletter will include the latest results discussed at the 3rd project meeting.

Additional information

Please visit the PEBS web site for more information on applying for the PEBS Bentonite training, workshop and field trip to Bavaria in October 2012.

For more detailed information see:

http://www.pebs-eu.de

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