BGE TECHNOLOGY NEWS

2023

Underground work at the Asse Mine (Germany)

BGE TECHNOLOGY GmbH

Representatives of BGE TECHNOLOGY GmbH at WM Symposia 2023 in Phoenix (Arizona)

Dear readers,

„Let's build it like this, try it out, and then see if it works!" This is the principle I often use when it comes to playing, doing handicrafts, or building things at home with my children (aged 6 and 9). This trial & error method and the striving for improvements and optimisations is inherent to many of us. In addition to gaining knowledge, it is also an incentive and drive for our actions. This approach is not only found in playing with the children, but also in professional practice – although the scale, the complexity, and the requirements („...show that it works!") are much higher. Laboratory tests as well as pilot plant or underground full-scale tests not only serve to determine properties, but also enable us to assess the feasibility and functionality of designs.

At BGE TECHNOLOGY GmbH, but also in our national environment, construction activities and experiments are currently taking place that are worth a closer look. For example, our parent company BGE currently plans several drift seals as demonstration structures for the closure of the ERAM repository for low- and intermediate-level waste. These structures will be constructed from sorel concrete in rock salt and anhydrite. BGE TECHNOLOGY GmbH provides support in the development of the long-term resistant building material, in logistics considerations, in the actual concreting, and in QA measures. Furthermore, we assist in the specification of the testing regime and by carrying out numerical calculations.

A further contribution to the safe containment of radioactive waste are injections. As part of the PRECODE project, we are developing and testing injection agents for sealing cracks and fissures in crystalline rock. Although we can draw on our experience in rock salt, the specific boundary conditions of crystalline rock still require some adaptations of injection agents and technologies in order to successfully go „from the lab to the field".

Against the background of the knowledge gained from large-scale tests, it is also pleasing to hear the news from the IAEA workshop on deep borehole disposal, where it is also intended to carry out a demonstration test. This disposal concept is especially interesting for many countries with only small waste inventories. Let's see. We will be keeping an ear to the ground.

But I do not want to get too far ahead of my colleagues. So...

Happy Reading!

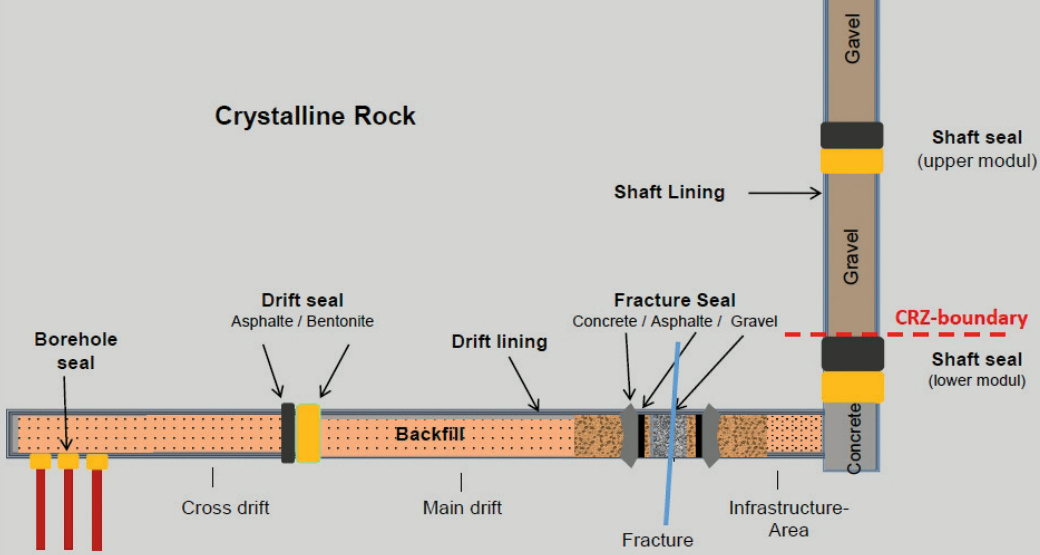
Mirko Polster

CHRISTA-III Project: Methodology for Developing Expected and Deviating Evolutions of a HLW Repository in Crystalline Rock

Through the Project Management Agency Karlsruhe (PTKA), the Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection has commissioned BGE TECHNOLOGY GmbH, BGR, and GRS with the research project CHRISTA-III.

The main objective of this project is to develop a methodology for deriving expected and deviating repository system evolutions in crystalline rock, which will be fundamental for evaluating the system's safety as required by the Ordinance on Repository Safety Requirements (EndlSiAnfV). In addition to repository system evolutions, complementary work packages deal with possibilities to increase the robustness by combining different disposal options, the further development of integrity analyses for crystalline rock, and strategies for optimising the repository concept in terms of long-term safety.

The current project builds on the results of the CHRISTA-II research project, which developed a safety demonstration methodology for HLW repositories in crystalline rock and prepared three comprehensive FEP catalogues for dif-



Schematic layout of the closure concept in crystalline rock – CHRISTA–III project

ferent disposal options. To test the safety demonstration methodology, scenarios for future repository evolutions must be developed in a systematic way. In the CHRISTA–II project, the basics for scenario development have been prepared – the safety concept and the corresponding closure concept (see figure) as well as the FEP–catalogue. Referring to this information, the CHRISTA–III project will examine the applicability of the methodology for scenario development previously proposed for salt and clay formations in the VSG and ANSICHT projects. Adjustments to the canister–based safety concept in crystalline rock have to be done. Finally, the applicability of the proposed methodology will be tested by examining the expected and deviating repository system evolutions.

Determination of Minimum Pillar Width in Opalinus Clay

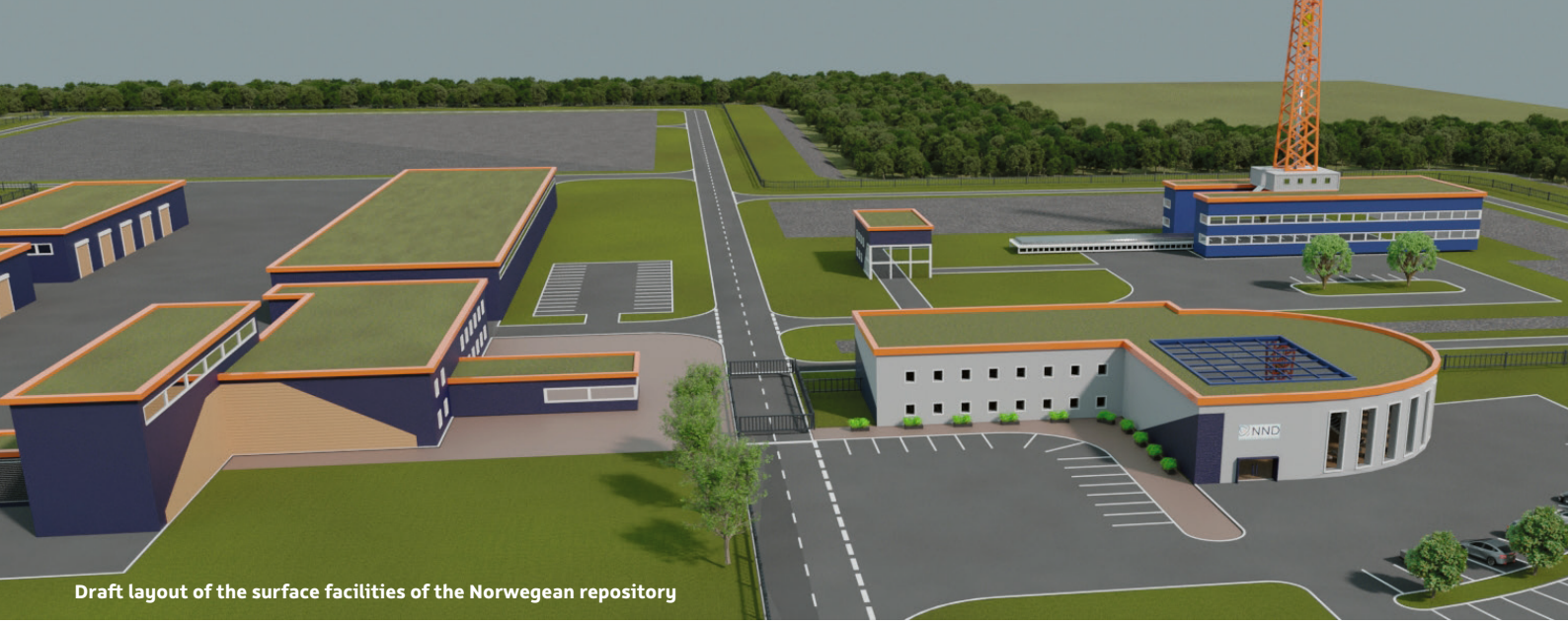
On behalf of the site selection department of BGE, a team from BGE TECHNOLOGY GmbH has dealt with the question of the minimum pillar size required between parallel emplacement galleries in Opalinus Clay viewed from a rock mechanical point of view. This task was a contribution to the calculation of the footprint of a repository for HLW and SF in Germany, which is a required step in the current site selection phase. The Swiss Waste Management Organisation, NAGRA, was so kind to provide provisional rock parameters for a potential repository site in Opalinus Clay.

The determination of pillar width was then performed in three different approaches: Use of empirical formulae based on mining experience, the analytical convergence–confinement method as used in tunnelling, and by numerical simulation. Empirical formulae for pillar design that have been successfully applied to Opalinus Clay do not exist. Formulae from room and pillar mining for sedimentary rocks of similar strength offered a large variety of results and were therefore inadequate. However, the convergence–confinement method and numerical simulation lead to very similar pillar widths in all relevant depths. Sufficient pillar width was in this case defined as stresses in the pillar centre being just below the dilatancy strength of the rock. Rock support was in both cases modelled as inner pressure onto the gallery contour. A major difference in the two approaches is that the convergence–confinement method is only applicable to round tunnels, whereas the emplacement galleries were of a curved shape. The curved shape was incorporated into the numerical model. The gallery shape proved to be irrelevant for pillar width design. In future work, rock behaviour and pillar design will be analysed taking into account coupled thermal, hydraulic, and mechanical processes.

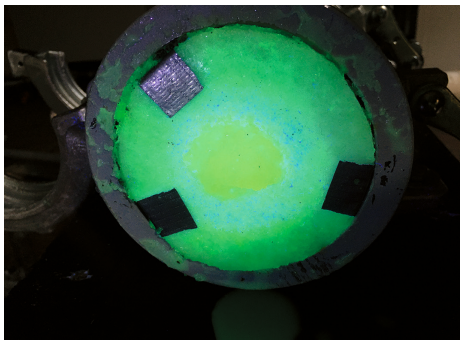
PRECODE Project: Upscaling Material Tests in Preparation of Underground Injection Tests

On behalf of BGE, BGE TEC is engaged in the PRECODE project in cooperation with the RWTH Aachen and Bedretto Labs. The main goals of the project are (i) to improve the understanding of the EDZ formation in crystalline rock, (ii) to test methods for near–natural fracture filling by means of injections in order to reduce rock permeability, and (iii) to develop a method to quantify the dilatancy and fluid pressure criterion in crystalline host rock for the preliminary safety assessments. BGE TECHNOLOGY GmbH focuses on the latter two objectives. For the injection techniques, the aim is to adapt the well established injection process developed for other host rocks to its use in crystalline rock. Crack injections will be carried out in order to determine the extent to which the containment effect in crystalline rock can be improved.

The starting phase of the project was characterised by an extensive laboratory programme to identify the most promising potential injection materials. Finally, a set of five water glass–based injection materials was identified. The group can be further separated into particle–free and particle–loaded materials. To be prepared for the actual in–situ tests, an upscaling of the laboratory tests was required. Respective upscaling tests are currently implemented. With respect to operation, the sensitivity of the mixtures to divergences, the handling of the materials, and their pumping behaviour are in the focus. Regarding performance, the behaviour in dry and wet conditions has to be investigated. To cover all the aspects mentioned above, a test rig made of different pipes was designed. The pipes will be filled with soil to create a defined porosity and permeability. Adding water allows the simulation of wet or completely watersaturated conditions.



Draft layout of the surface facilities of the Norwegean repository


Pressure test using water with Uranin tracers. Project PRECODE

Instead of handling only a few tens of millilitres, the test rig allows the handling of a more realistic amount of injection material. In each pipe, up to 20 litres of material are used. Through these tests, the project team learned more about the usability of the different materials. The measurement uncertainty of the weighing device used, for instance, influences the reaction time of some of the materials. As a result, mixing in situ should be avoided and a more accurate premixing of components should be preferred. Other materials show a perfect flow and distribution under dry conditions but tend to agglomerate under wet conditions. The lessons learned will be used to further detail the test plan for the in-situ experiments.

IAEA Workshop on Deep Borehole Disposal

Deep borehole disposal of radioactive waste is a topic that is being lively discussed all over the world especially for specific waste streams. In order to summarise the current state of knowledge and identify potential research and development needs, the IAEA set up a consultancy meeting where these topics were discussed in general. The desired outcome of this meeting is a potential Coordinated Research Project (CRP).

The participants who attended this workshop come from different countries, regions, and organisations from all over the world. All agreed that a great outcome of the CRP would be a demonstration borehole, which would represent a milestone for the further development and implementation of deep borehole disposal. Furthermore, a list of technical topics of interest was discussed. These include emplacement equipment, canister design, and the overall topic of backfilling and sealing – all topics, where BGE TECHNOLOGY GmbH (BGE TEC) has carried out work in the past. The DENKMAL project, for example, was brought forward several times. Part of this project was a large-scale demonstration test for the emplacement of HLW canisters in boreholes, where BGE TEC was mainly responsible for the design of the emplacement device as well as the implementation of the tests. Partners then carried out the fabrication of the components. Ultimately, the demonstration test was carried out successfully. With our comprehensive involvement in canister development and design projects as well as the work recently carried out for NND in Norway and CSIRO in Australia, BGE TEC can certainly contribute to the CRP. In order to develop a scientific and technical basis, the expertise of BGE TEC is of relevance as well. Here, the extensive knowledge and understanding of materials used for the construction of drift seals as well as the general design of sealing systems was of interest. The main task and deliverable for BGE TEC is to prepare an overview of sealing materials for all types of sealing systems.

For the time being, a first distribution of tasks has been recorded in a workshop protocol, which is being compiled by the colleagues of IAEA in order to develop a project outline. With this in hand, the general research project can then eventually start and push the deep borehole disposal option forward.

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