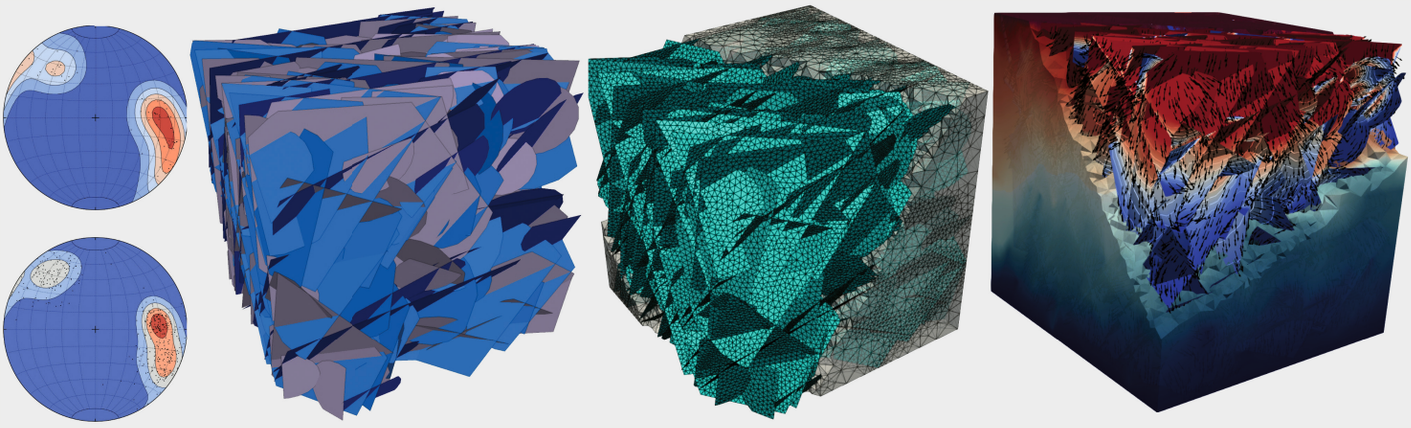
# BGE TECHNOLOGY NEWS

2 2024

**Drift cutting work in salt formations at Asse mine (Germany)**

BGE TECHNOLOGY GmbH



**Model data reflecting discontinuity orientations of field data (plots of poles, left)**
**Right: Conversion of fracture network into finite element discretisations (R&D project PRECODE)**

Dear Readers,

A little more than one year after restructuring BGE TECHNOLOGY GmbH into a matrix organisation to facilitate project acquisitions and project management, we are in the home stretch of introducing some major improvements in the way we control and report our projects alongside some useful optimisations in our quality management structure.

I am very happy to say that all the department and division heads work well together in continuously improving quality and performance of the company. There is plenty of initiative to tackle all the small issues that no single person is obviously responsible for.

However, when administration is a significant part of the job, there is always the risk to overestimate the usefulness of administrative measures. At the end of the day, the most important aspect of company performance is to have the right people on the job and not to waste their time filling out "Quality Control Sheet A38". So, at every step on the way, we need to ask ourselves if what we try to implement has a good cost to benefit ratio. It is easy to overload a company with internal administrative requirements.

After all, everything we do has to serve the scientific and technical work in our projects. For this purpose, we strive for well-balanced and efficient procedures that fulfil the high quality requirements of our clients.

I'm happy to present to you this quarter's selection of ongoing projects.

Happy reading!

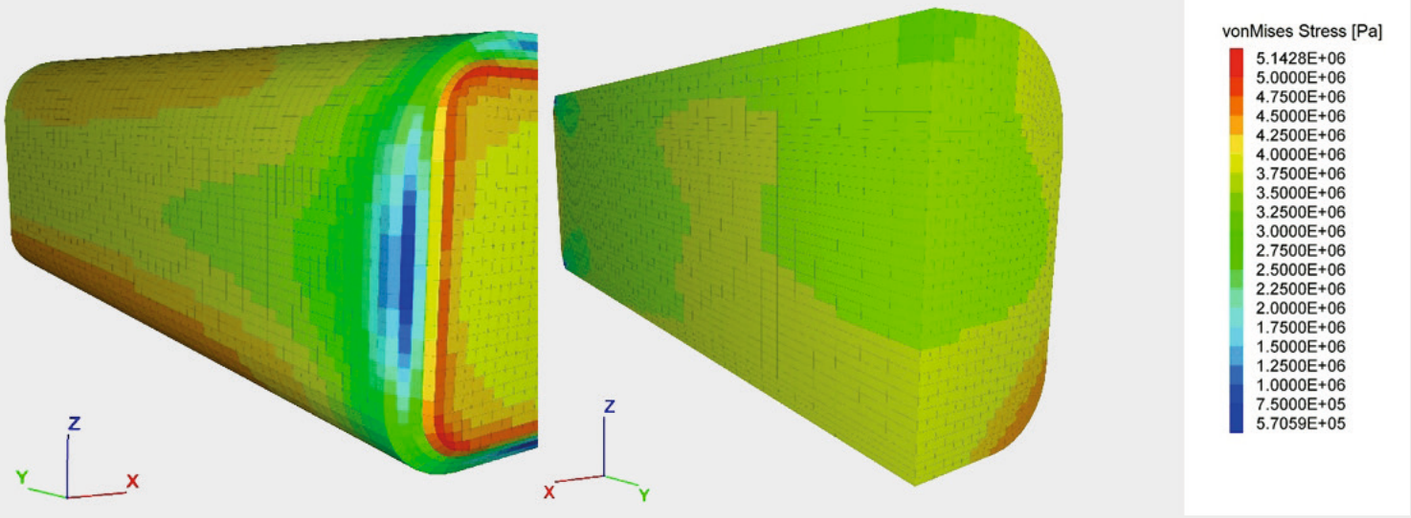
Niklas Bertrams
Head of National Projects Division

## Fracture Modelling in Crystalline Rock

BGE TECHNOLOGY GmbH works jointly with RWTH Aachen on the BGE-funded R&D project PRECODE, which aims at deepening our understanding of crystalline rock. For this purpose, data have been acquired from experiments in 3 boreholes of 10-m-length in the Bedretto underground laboratory in Switzerland. As the performance of the geological barrier in crystalline formations strongly depends on fracture or foliation planes that govern the rock's hydraulic and mechanical properties, a key challenge is the description of these discontinuity sets. Only limited data are available from outcrops (2D) and boreholes (1D), whereas most 3D representations are usually the result of upscaling. For a more reliable incorporation of field observations during model development, an automated workflow for the statistical analysis and model parameter extraction is currently being developed by BGE TECHNOLOGY GmbH. The results are validated statistically and calibrated by field observations to ensure consistency between modelled and observed data. The derived geometries can be meshed and used to characterise rock masses in terms of their stability and for evaluating other safety-related criteria numerically. For this purpose, the developed workflow is currently applied to data from the Swiss underground laboratory and further extended. As the integrity of the geological barrier needs to be demonstrated, methods to quantify the dilatancy and fluid pressure criteria in crystalline formations will be tested in the project as well.

## „...With a Little help..." – Current Modelling Work of BGE TECHNOLOGY GmbH in Support of BGE's Projects

Currently, we carry out supporting activities in the form of numerical modelling in several subject areas for the projects of our parent company, BGE. One focus is the work for the planning of the decommissioning of the Mors-




**Results of modelling creep-induced mechanical loading of a drift seal at the Morsleben repository (Germany)**

leben repository. The effectiveness of backfilling and sealing measures is analysed and verified by means of calculations. On the one hand, this concerns the simulation of the planned backfilling measures in the mine workings with the aim of maintaining the integrity of the geological salt barrier. On the other hand, the stability and functionality of geotechnical barriers – in particular of the 25 planned drift seals – are being analysed. In variant calculations, the site-specific boundary conditions of the sealing locations (such as cross-section shape, depth, creep capacity of the surrounding salt, etc.) are taken into account. The Sorel Concrete MO1 construction material intended for use and newly developed by BGE TEC in cooperation with BGE is currently being analysed in laboratory and underground in-situ tests. The close monitoring of the tests is used for the parameterisation and verification of the MO1 material model.

A second focus is technical assistance for BGE in its participation in two EU projects as part of the European Joint Programme on Radioactive Waste Management (EURAD). We already reported on this project in our Newsletter IV/2023.

Another focus is the technical support of BGE when the geomechanical modelling is carried out by external contractors/subcontractors. Our tasks here range from the technical coordination and monitoring of the modelling services to the checking and quality assurance of results and documents from external contractors. This concerns assistance in the ASSE and KONRAD projects and for the site selection department.

## Norwegian Nuclear Decommissioning is Moving to the Next Phase In Their Radioactive Waste Management Programme With the Help From GeoReN Group

Norwegian Nuclear Decommissioning is a governmental agency of the Norwegian Ministry of Trade, Industry and Fisheries responsible for radioactive waste management, including disposal. BGE TECHNOLOGY GmbH has been supporting NND since 2020 together with the Finnish partners AINS Group, Geological Survey of Finland, the Mitta Group, Posiva Solutions Oy, and VTT Technical Research Centre, with Rambøll (Norway) as a subcontractor. The group continues to work under the name GeoRen (Geological Repositories for Norway) and assists NND in the development of the disposal concepts, technical design, and safety aspects for the disposal of spent fuel and other radioactive waste in Norway.

NND has been assigned the responsibility of decommissioning the Norwegian nuclear facilities located at Halden and Kjeller. Additionally, NND is responsible for developing and constructing storage facilities and repositories for all radioactive waste.

GeoReN has been carrying out a disposal concept choice study since 2023. Its purpose is to propose potential disposal concepts and to assess their suitability for managing the Norwegian radioactive waste. To evaluate disposal options, a transparent 7-step assessment strategy was developed, enabling a systematic evaluation of the suitability of various disposal concepts for Norway's waste inventory. This method evaluates disposal concepts and justifies the evaluation outcome. Recommendations for suitable disposal concepts and their further development are provided. Norwegian regulatory requirements, international experience, and previous Norwegian studies have been analysed to support the evaluation. Currently, the evaluation of disposal concept options will not consider any specific repository sites in Norway. Norwegian geology will be considered as a factor for the suitability of specific concepts. The evaluation of repository concepts will take into account the restrictions to find a suitable site in Norway in general. This includes the possibility of ruling out concepts as unsuitable for any geological environment in Norway.

## The SalVE Project – Are Molten Salts Able to Improve Engineered Barriers in Rock Salt?

In cooperation with the Institute of Inorganic Chemistry at TU Bergakademie Freiberg and supported by the Institute of Geomechanics GmbH Leipzig, BGE TECHNOLOGY GmbH carried out a feasibility study on the suitability of molten salts as backfilling and sealing materials for repositories in rock salt formations funded by the Project Management Agency Karlsruhe on behalf of the Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection (BMUV). The key findings of the project can be summarised as follows:

The experimental results clearly show that using molten salts with low melting temperatures as sealing materials is a challenge. Still, the selected molten salt NaCl-$AlCl_3$ with its different set of properties compared with other conventional sealing materials is able to add a complementary behaviour to the engineered barrier system (EBS). As ex-

Korean delegation visited BGE TECHNOLOGY GmbH

pected, it fills cavities and builds a firm bond with the surrounding rock salt. At the same time, it develops a microcrack system and, at laboratory scale, a funnel shape on the surface that both origin from the cooling process. While the solidified pure molten salt only reaches a gas permeability of around K = $10^{-16}$ m², a test with NaCl solution indicated a decreasing permeability by crystal precipitation over time. During this process, the volume of the material increases and if confined, builds up a pressure that may be able to compress fractures, which effectively reduces the internal permeability as well as the permeability of the excavation damaged zone. Compared with rock salt, the pure molten salt is characterised by a low compressive and tensile strength. If crushed salt is added, both values improve and reach about 50 % of the strength of rock salt. In the temperature range of up to 200 °C used, only a fixed ratio of the two salts NaCl and $AlCl_3$ melts. Therefore, crushed salt with a higher melting temperature remains solid and improves the material's strength. The handling of the molten material in the mine is another challenge. Molten salts require heat energy, a transportation system for heavy hot liquids, and customised safety measures. Even though these challenges can be met, a sophisticated production system needs to be in place. A final evaluation of the use of molten salt in the EBS in rock salt will be given in the final report.

## Compaction of Crushed Salt for Safe Containment

Long-term sealing elements for drifts and shafts are essential in the safety concept for a repository for heat-generating, high-level radioactive waste in rock salt. They are constructed by means of qualified granular salt. The function of granular salt as a geotechnical barrier represents a paradigm shift in the safety function of crushed salt. In the past, granular salt was primarily considered in terms of its suitability as a backfill material with a support function for the surrounding host rock. Demonstration of long-term functionality is essential for the use of crushed salt as a geotechnical barrier. It is assumed that barrier effectiveness is achieved during the compaction process.

The KOMPASS-II project was an international joint R&D project of BGE TECHNOLOGY GmbH, BGR, COVRA (Netherlands), GRS, IfG Leipzig, Sandia National Laboratories (USA), TU Clausthal, and Utrecht University and ran from 2021 to 2023. The final report has been completed in January 2024. The project was funded by the Project Management Agency Karlsruhe on behalf of the Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection (BMUV). The project dealt with the investigation of the compaction behaviour of crushed salt. The aim was to improve the understanding of the thermal-hydraulic-mechanical coupled processes and thus to enhance the scientific basis for the use of granular salt for the long-term containment of heat-generating, high-level radioactive waste in rock salt. For this purpose, experimental studies based on long lasting compaction experiments were combined with microstructural investigations and numerical modelling. The aim of the numerical modelling was a suitable description of the compaction process with the influencing quantities as well as a robust and reliable prediction of long-term safety with validated constitutive models.

The investigations focused on the influences of the mean stress, the deviatoric stress, and the temperature on the compaction behaviour of crushed salt. The microstructural investigations dealt with the influences of the pre-compaction method, the moisture content, and the grain size/grain distribution on the microstructural deformation mechanisms and their contribution to the overall compaction of crushed salt. Based on the experimental data obtained, the material models were improved and suitable parameter sets were identified with respect to chosen experimental data. Calculations with a virtual demonstrator were used to compare the results of the project partners.

For further information, visit www.bge-technology.de or scan the QR code below.

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