BGE TECHNOLOGY NEWS

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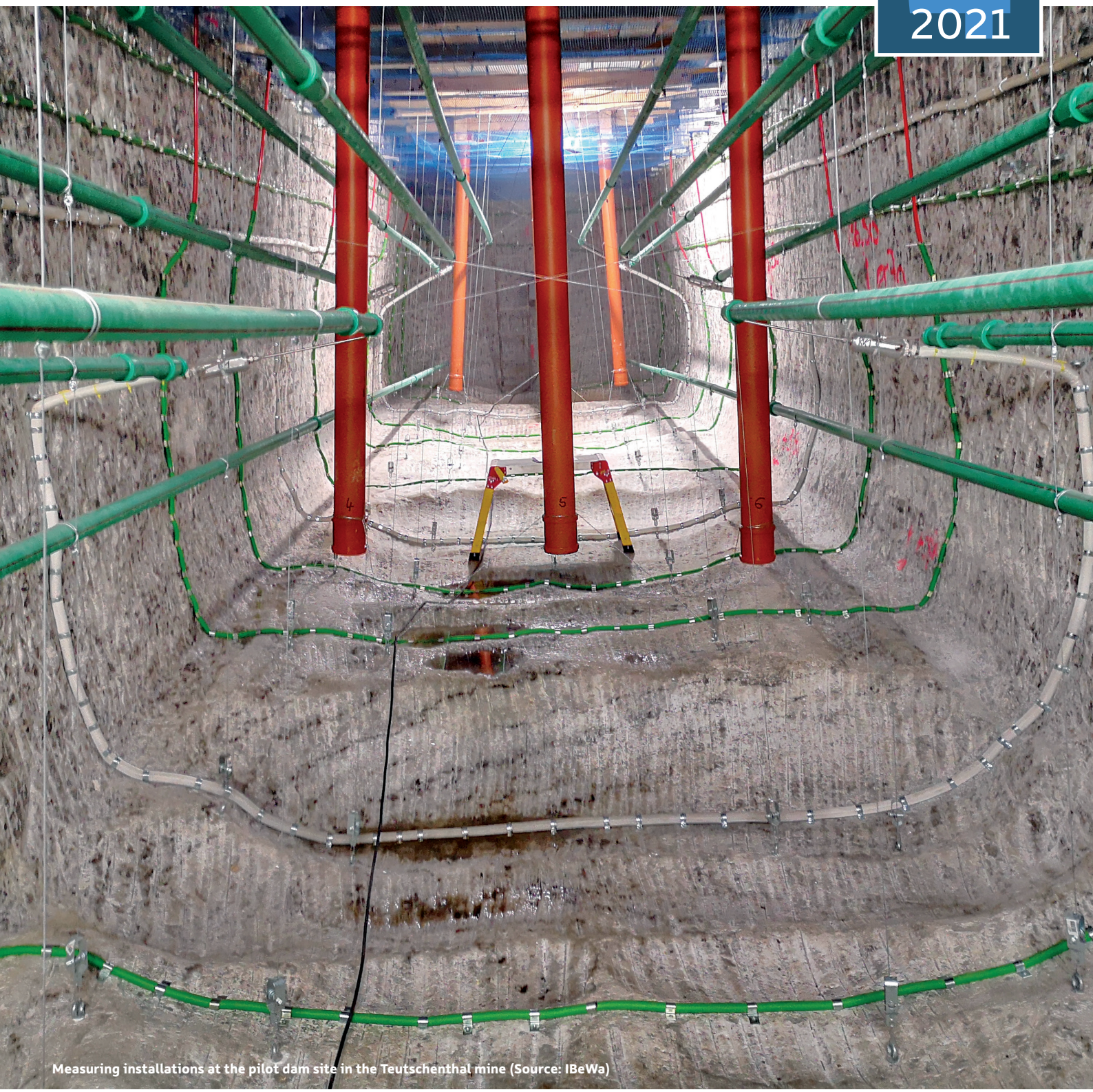
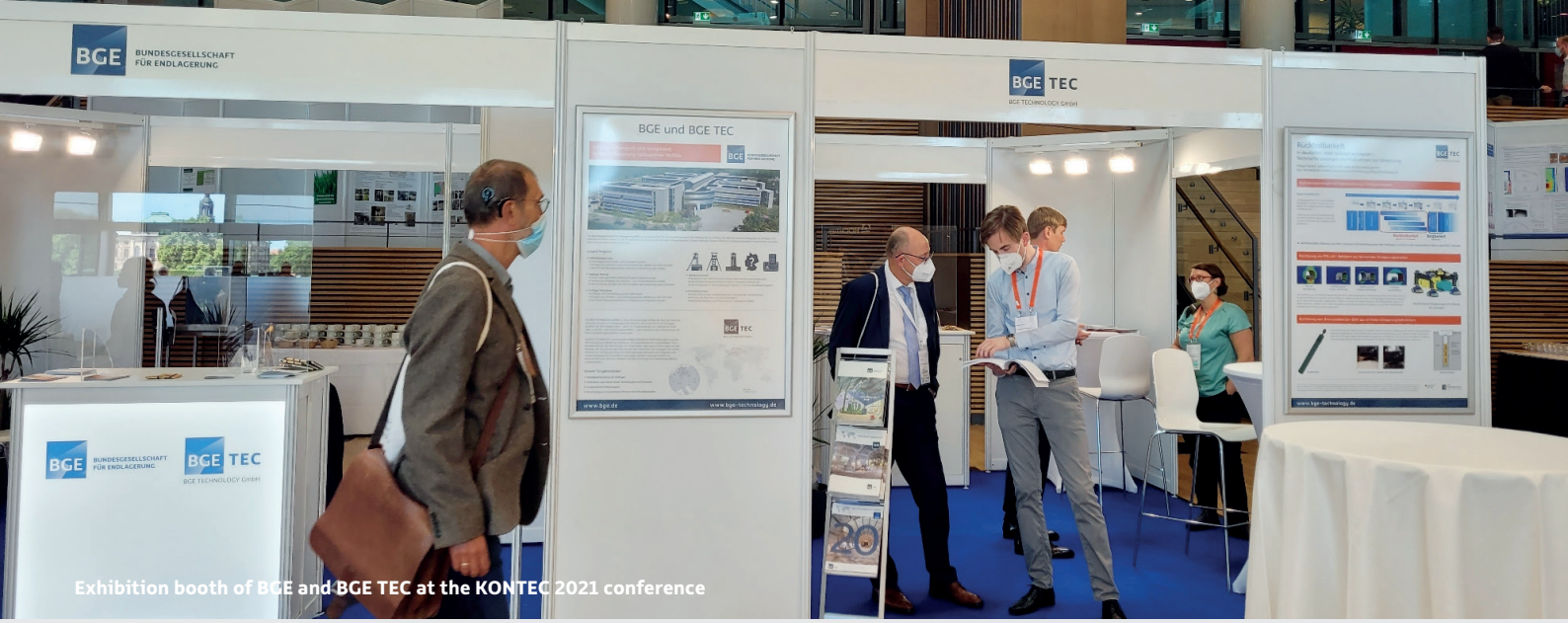


Measuring installations at the pilot dam site in the Teutschenthal mine (Source: IBeWa)

BGE TECHNOLOGY GmbH

- 4TH MEETING OF THE CRYSTALLINE CLUB
- MOLTEN SALTS AS ALTERNATIVE BACKFILL AND SEALING MATERIALS FOR A REPOSITORY IN ROCK SALT
- THE STROEFUN PROJECT – CONCRETING OF A PILOT DAM
- EDZ EVOLUTION IN CRYSTALLINE ROCK AND DEVELOPMENT OF SUITABLE INJECTION TECHNIQUES



Exhibition booth of BGE and BGE TEC at the KONTEC 2021 conference

Dear Readers,

I think we all are aware that the main driver for progress is innovation. This is true for the industry and the market in general, and for the development of technical and methodological solutions for the disposal of high-level radioactive waste as well. Although significant innovations are only rarely born in the field of radioactive waste disposal and their implementations take longer than in the industry, there have been several in the past and more are expected for the future. Let me give you several examples:

The development of a common understanding of a safety concept for the disposal of high-level radioactive waste took several years of R&D work and discussions with the authorities in Germany. In the end, the resulting safety concept – proposed by the German scientific community – was accepted by the German authorities and subsequently included in national legislation.

Another example is the issue of retrievability of emplaced waste packages. In this case, the legal requirement was set first; but in due time, engineers developed safe solutions for the technical realisation of retrieval. At least on a conceptual level, technical solutions for the retrieval of waste packages from different host rocks are available now.

A future challenge is the implementation of AI (artificial intelligence) in safety assessments and its implementation in combination with robotic systems in processes during repository operation. This will take time, but I am sure that in due time, concerted actions of R&D will lead to a practical solution and to helpful applications.

This newsletter introduces some projects of BGE TECHNOLOGY GmbH that deal with generic R&D work in the field of radioactive waste disposal in crystalline rock and rock salt. All of them contribute to the progress in repository safety. So, the behaviour of crystalline rock is the subject of investigations and discussions (project PRECODE and the NEA Crystalline Club). For rock salt, potentially new sealing materials are being investigated (project SalVE), and the behaviour of sealing structures will be analysed (project STROEFUN in the German Teutschenthal mine).

Time goes by! After more than three decades of working in the field of research and development in radioactive waste disposal and heading and motivating a team of highly qualified scientists and engineers, it is time for me to retire and to say goodbye. I wish you all the same pleasure I had in contributing with my team to the progress in developing solutions for high-level radioactive waste disposal.

Farewell and Happy Reading!

Wilhelm Bollingerfehr

Head of Research & Development Department

4th Meeting of the Crystalline Club

The 4th meeting of the Expert Group on Geological Repositories in Crystalline Rock Formations (Crystalline Club, CRC) took place as a virtual event from 1–3 June, 2021. In 2016, the Integration Group for the Safety Case (IGSC), the main technical advisory body to the OECD Nuclear Energy Agency Radioactive Waste Management Committee (NEA RWMC), approved the launching of the CRC. The key objective of the Crystalline Club is to promote the exchange of information and to share state-of-the-art approaches and methods to improve the understanding of crystalline rock as host rock for high-level radioactive waste repositories. Traditionally, the CRC meetings are supplemented by topical sessions that are associated with the CRC mission. In 2019, the 3rd meeting in Krasnoyarsk, Russian Federation, addressed the problem of identifying key data to be obtained from crystalline rock that are relevant to the safety assessment process. The current meeting was about the comparison and evaluation of the trans-

Concreting of a pilot dam at the Teutschenthal mine (Source: IBeWa)

fer of data for generating descriptive and safety assessment models. BGE TECHNOLOGY GmbH contributed to the topical session with a presentation about "Key aspects of safety concepts in crystalline host rock". In 2022, the 5th CRC meeting is to be held in Dresden, Germany.

Molten Salts as Alternative Backfill and Sealing Materials for a Repository in Rock Salt

In August 2021, the Project Management Agency Karlsruhe, PTKA, (on behalf of BMWi) commissioned both the Institute of Inorganic Chemistry at TU Bergakademie Freiberg and BGE TECHNOLOGY GmbH with the joint R&D project SalVE to investigate the suitability of molten salts with low melting temperatures as backfilling and sealing materials for repositories in rock salt formations. The Institute of Geomechanics GmbH Leipzig will support the project with advanced numerical calculations.

Molten salts are pure or mixed salts that have been heated above their melting temperatures. They can be poured or pumped into a prepared backfilling or sealing location, where they cool down and solidify. Due to the application in their liquid states, the materials may build up a close connection with the surrounding rock and fill uneven contours or voids. The materials are supposed to solidify without significant porosity, leaving hardly any space for convergence or for potential fluids to squeeze out over time. With a targeted melting temperature between 100 °C and 200 °C, the molten salts themselves are free of water and therefore do not transport any water into the repository. Furthermore, the water-free solids are assumed to create a pure solid-state diffusion and hence complete containment of radionuclides. Consequently, the molten salts are potentially able to seal repositories in rock salt instantaneously and on a long-term basis.

The objective of the project is to assess the suitability of molten salts for their application in underground salt repositories in defined locations. Among others, this will include studies on health and safety, geological constraints, and mining requirements. The goal is to identify molten salts with beneficial strength, permeability, and shrinkage properties that are chemically stable against typical rock types and potential solutions. If such a material is found, a processing, transportation, and application procedure will be described to ensure that large-scale trials can be carried out later.

The STROEFUN Project – Concreting of a Pilot Dam

The hydraulic resistance of drift seals is determined by three elements that act in parallel – the seal's body made of magnesia-based concrete, the excavation damaged zone (EDZ) close to the drift contour, and the contact zone between the seal's body and the drift contour. Within the joint R&D project STROEFUN, a method to test the permeability of the contact zone along the entire contour of a seal's cross-section has been developed. To test this method, an in-situ test is carried out in the Teutschenthal salt mine (Eastern Germany).

At the beginning of August 2021, several layers of site-mixed MgO-concrete were emplaced to form the lower part of a seal´s body – a half dam. Before starting concreting, measuring and monitoring devices were installed in the drift, and a stage was constructed above the future top of the half dam in order to monitor the setting process. The concreting was carried out in five shifts, each shift lasted ten hours. Two compulsory mixers ensured a continuous production of building material. The mixers were loaded with salt grit from pre-filled big bags. A specially designed system controlled the subsequent addition of MgCl solution. In addition, this system provided visual signals, which indicated when to add the MgO to the mixer. This procedure ensured that each batch was mixed for the same duration and therefore received the same amount of energy from the mixing process. Then, the suspension was pumped into the allocated space of the drift. Regular checks of the concrete suspension throughout the whole operation ensured the material´s quality. During the entire concreting period, no interruptions or incidents worth mentioning happened, so that after 149 batches, a total volume of roughly 100 m³ MgO-concrete was placed behind the formwork.

Another special feature was the measuring of temperature and pressure values at measuring points in and around the half dam, the results of which were displayed in situ on a screen in real time. First data analyses showed that the temperatures inside the core of the MgO-layers exceeded 100°C, confirming previously calculated values. The next steps are to evaluate the measured pressure data in detail. Also, permeability measurements by means of the installed system within

The access tunnel of the Bedretto URL (Switzerland)

the structure as well as in the contour zone will start soon.

The R&D project STROEFUN is funded by the Project Management Agency Karlsruhe on behalf of the Federal Ministry for Economic Affairs and Energy and managed by the technical university of Clausthal. Among others, BGE TECHNOLOGY GmbH is responsible for the quality assurance concept for building material testing and its implementation and for evaluating the results of the quality assurance. Furthermore, we carried out model-based prognoses as a basis for the testing.

EDZ Evolution in Crystalline Rock and Development of Suitable Injection Techniques

The excavation of mine openings as well as time-dependent brittle fracturing around drifts may lead to an interconnected fracture network (i.e. excavation disturbance zone or excavation damaged zone; EDZ) and thus provide pathways for radionuclide migration. To improve the knowledge about EDZ characteristics and evolution in brittle rock, RWTH Aachen in collaboration with the Swiss Federal Institute of Technology (ETH) and York University initiated the PRECODE project, and BGE TECHNOLOGY GmbH joined the project as well. The joint project is funded by BGE. The general project goals 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 will focus on the latter two objectives. Using injections for systematic rock improvement has not yet been envisaged in any repository concept. In addition, it is of great interest for the German concept of safe containment to examine whether it is possible to produce natural-like, long-term stable fracture fillings by means of injections. The use of such injections has already been investigated for the crystalline rock in Scandinavia, but was not pursued further because the Scandinavian safety concept is different from the German one. BGE TECHNOLOGY GmbH has developed injection procedures for the Asse II mine, which is located in rock salt. Here, the injections can by now be applied as a standardised process chain (materials, technology, evaluation), and the hydraulic resistances of the injected areas can be verified in accordance with the requirements. One aim of the new R&D project PRECODE is therefore to adapt the injection process developed by BGE TECHNOLOGY GmbH to its use in crystalline rock and to carry out crack injections in order to determine the extent to which the containment effect in crystalline rock can be improved. RWTH will run an excavation of a new drift, combined with a detailed monitoring programme to investigate the EDZ development during excavation (mine-by experiment). The injection tests as well as the mine-by experiment of RWTH will be carried out at the Bedretto Underground Lab. Here, ETH Zurich has established a new underground research laboratory. The core facility of the URL is within the Rodondo Granite at a depth of approximately 1100 m. The rock around the old tunnels is massive to moderately fractured and systematically affected by brittle failure processes that form an EDZ. Thus, the URL offers a unique possibility for scientific research associated with the initiation and time-dependent evolution of the EDZ and of potential pathways in crystalline rock at depth.

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

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