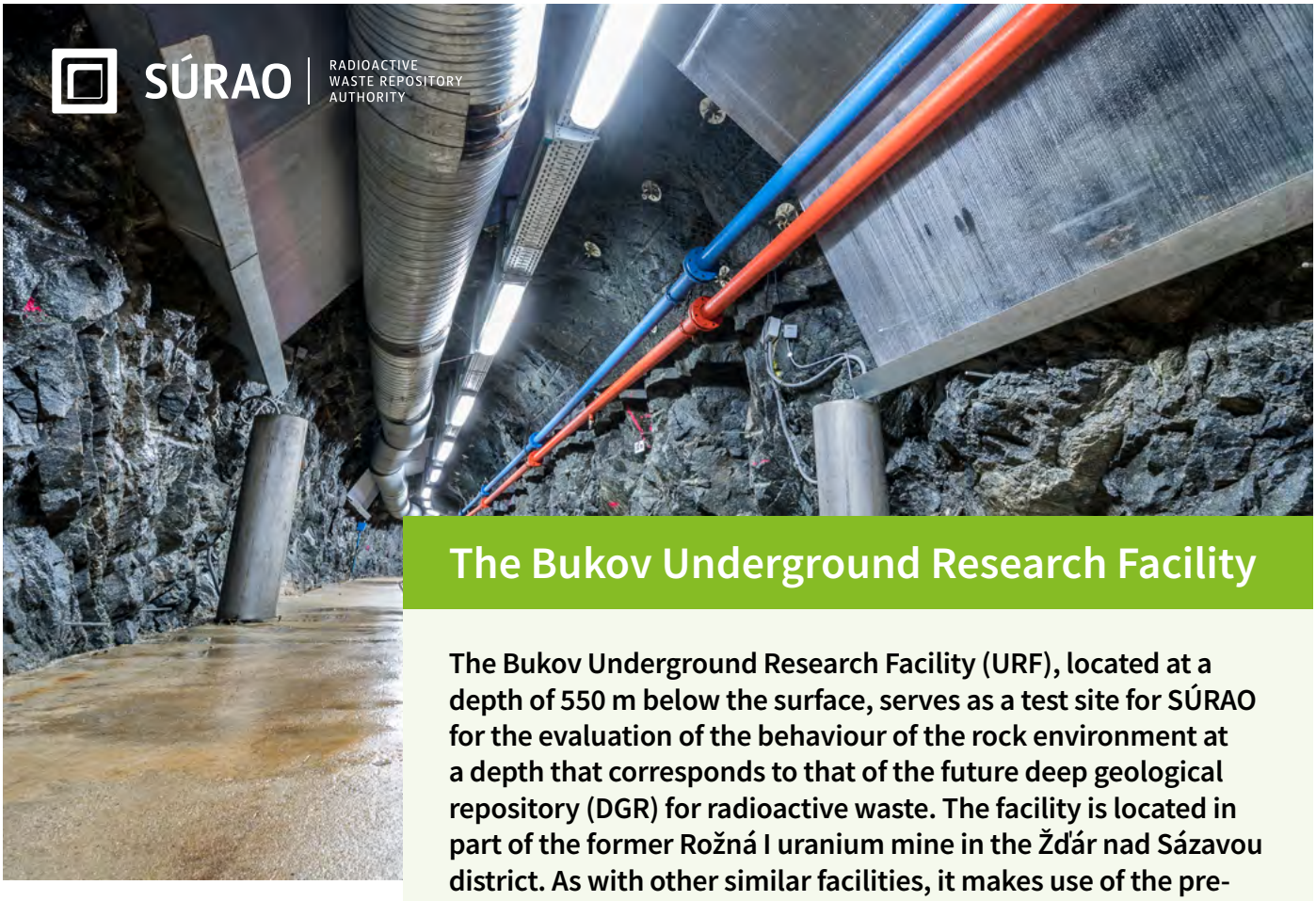

The Bukov Underground Research Facility

The Bukov Underground Research Facility (URF), located at a depth of 550 m below the surface, serves as a test site for SÚRAO for the evaluation of the behaviour of the rock environment at a depth that corresponds to that of the future deep geological repository (DGR) for radioactive waste. The facility is located in part of the former Rožná I uranium mine in the Žďár nad Sázavou district. As with other similar facilities, it makes use of the pre-existing underground mine infrastructure.

The laboratory areas of the Bukov URF are located in the southern part of the mine on level 12 of the B-1 working, and are being used for research and development and the conducting of demonstration experiments for the purposes of the Czech DGR development project. The indispensable role of underground research laboratories in the DGR development process is acknowledged internationally. They are used, for example, for the development of methodologies for the description of the rock environment and for obtaining data intended for the testing of mathematical models that serve to prove the safety of the DGR concept. They also provide for the conducting of in-situ experiments focusing on the development, behaviour and optimisation of the various components of the repository. The data and experience obtained also play an important role in the DGR site selection process. Since 2017, most of SÚRAO's research activities involving in-situ experiments have been conducted at the Bukov URF.

The Bukov URF project:

1. Construction phase (2013–2017)

The construction of the Bukov URF commenced in 2013 and was completed in 2017. The exploratory phase included the excavation of a 300 metre-long access crosscut which was followed by a drilling campaign aimed at specifying the geological structure and the selection of the rock blocks. The final phase consisted of the excavation of the experimental chambers. The construction of the laboratory areas involved the application of the contour blasting method that allowed for high-quality excavation without the need for reinforcement.

2. Characterisation (2015–2017)

The aim of this stage was to compile a description of the rock environment for the emplacement of experiments and to obtain data concerning the opening of the rock massif as a result of excavation activities. The following areas were subjected to detailed research: the geological structure, geotechnical properties, hydrogeological properties, seismicity and the transport properties of rock. The various outputs of this stage included the creation of a geological and geomechanical model of the Bukov facility. This stage also included the compilation of a description of the development of selected parameters of the rock environment with depth such as the composition and age of the groundwater and the quality of the rock mass.

3. Experimental programme (from 2017)

The experimental programme includes a broad range of activities related to the Czech DGR development programme. The results of the various experiments will serve, for example, as the basis for the evaluation of the rock mass and the behaviour of processes at the anticipated depth of the repository with regard to the technical feasibility and safety of the DGR. The research programme is divided into seven areas referred to as REPs (research and experimental plans):

REP1: Characterisation research and the creation of geoscientific models of the rock environment

This research area includes activities aimed at the gathering of descriptive geological data, the storage of the data and its interpretation in the form of 3D models. It also focuses on the development of general methods for the description of the rock environment. Moreover, the research covers the gathering of data from geological surveys of the surface of the site and the various levels of the Bukov mine, the results of which are then used for the creation of 3D geological, hydrogeological and geomechanical models of the whole of the site. In 2020, the Deep Horizons project (2017–2020) was concluded. The aim of the project was to obtain spatial geological data from the 12th to 24th levels of the Rožná I mine. The laboratory and in-situ research focused mainly on the development of the geotechnical parameters of the rock mass with depth, the characteristics of the excavated damaged zones (EDZ) of the underground passages and the definition and detailed description of the homogeneous rock blocks. One of the most important parts of the project comprised the study of the so-called "first zone" of the mine. The project resulted in a significant advancement in the understanding of the influence of major tectonic zones on the failure of the rock mass for the purposes of the safe siting and overall design of the DGR.

REP2: Long-term monitoring of the rock environment

The focus of this research area comprises the testing and development of methods for the long-term monitoring of processes underway at DGR depth, including, for example, the monitoring of the development of microbial settlement, the groundwater parameters and the movement of brittle structures. This area also includes projects that consider the development of non-invasive geophysical methods for the study of rock masses. The following projects are currently underway:

- The hydrogeological and hydrochemical monitoring of groundwater and mine water (2018–2023). This project involves the long-term monitoring of the development of the yield and changes in the chemistry of water in a rock block from the surface to the theoretical depth of the DGR. The aim is to verify the influence of the underground structure on the hydrogeological regime of the site. The project is providing data for the calibration of hydrogeological models of the DGR candidate sites.
- The monitoring of the activity of brittle structures (2018–2022). The aim of the project is to enhance current knowledge on the movements of brittle structures in crystalline rocks at DGR depth, for which a monitoring network has been created that provides data on the behaviour of various generations of brittle tectonic structures.
- The long-term monitoring of the rock mass at the Bukov URF via non-destructive geophysical methods (2018–2022). The project involves the development and testing of a measuring system that uses the geoelectric and seismic properties of the rock mass and that allows for the long-term monitoring of changes in these properties in the immediate vicinity of the underground mine working. The experimental setup includes devices for the conducting of electrical resistance tomography and seismic measurements.
- The monitoring of anaerobic microbial settlement at the Bukov URF and the research of the relationships between the rock environment and microbes (2020–2021). This project follows on from the microbial screening performed at the Bukov URF in the period 2017 to 2019. The microbial settlement at the Bukov URF and in the wider vicinity of the Rožná I mine was characterised as being strongly anthropogenically influenced, represented mainly by the presence of aerobic microbe types. This follow-up project is focusing to a greater extent on anaerobic microbial activity, which has not yet been accurately described for the Bukov URF.

REP3: Groundwater flow and the transport of radionuclides

This experimental area is concerned with the research of groundwater flow and the transport of radionuclides in the rock environment of the DGR, including the testing and verification of modelling tools. The research of fracture connectivity project (2019–2024) is currently underway, the aim of which is to enhance the understanding of the advective transport of substances in the fracture systems of crystalline rocks. The project involves the gradual creation of a network of experimental boreholes in a selected rock block for the conducting of hydraulic and tracer tests, accompanied by the geological and hydrogeological modelling of the rock block of interest for the purposes of the further development of modelling tools and subsequent simulation testing.

REP4: DGR engineered barriers

This experimental area addresses the development and verification of the characteristics of the materials to be used in the disposal system and the waste disposal packages (WDP). The aim is to determine the rate of their degradation and mutual interactions under real DGR conditions. For example, the Interaction Experiment (2017–2022) is focusing on the study of the mutual interactions between the materials that make up the engineered barriers of DGR and their interaction with the rock environment and the groundwater. The experiment comprises a total of ten physical models emplaced in boreholes. Five of the models were designed for the study of interactions at ambient temperatures and the other five for the study of interactions at elevated temperatures, i.e. up to 200°C. A project aimed at the research of the corrosion resistance of the WDP candidate materials is in the preparation stage.

REP5: Influence of the construction of the DGR underground workings on the rock environment

The research work is concerned mainly with the description of the extent and character of the excavation damaged (EDZ) and excavation disturbed (EdZ) zones created via the methods employed for the construction of the underground areas of the DGR. A pilot project on this theme was conducted at the Bukov URF as early as during the excavation of the underground spaces of the facility (the creation and monitoring of the EDZ during the construction of the Bukov URF project, 2015–2018). One of the aims of the project was to compare the extent and properties of the EDZ/EdZ areas in the underground corridors created by the standard excavation and the so-called smooth excavation methods. The best results in terms of the interpretation of the EDZ/EdZ were obtained via the application of the electrical resistance tomography method. A more extensive project on this issue is planned in the near future.

REP6: Technological procedures concerning DGR construction

During the construction of the DGR, it will be necessary to apply a number of technological procedures that are not commonly used in standard commercial excavation projects, e.g. specialised uncoupling and drilling approaches. Research in this area, therefore, focuses on the development of new methods for the construction of underground workings in terms of the optimisation of both time and financial considerations.

REP7: Demonstration experiments

The research concerns the conducting of comprehensive experiments aimed at the testing of the behaviour of various elements of the disposal system at the real scale and under conditions corresponding to those of the future DGR. Such experiments involve particularly the testing of handling technologies, the construction of experimental models and the monitoring of processes.

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