SÚRAO | RADIOACTIVE WASTE REPOSITORY AUTHORITY

Bukov Underground Research Facility

The Bukov Underground Research Facility (URF) serves as a test site for the Radioactive Waste Repository Authority (SÚRAO) for the assessment of the behaviour of the rock environment at a depth that corresponds to that of the future Czech deep geological repository for radioactive waste (DGR). The facility's laboratories are located approximately 500 metres below the surface and make use of the infrastructure of the former Rožná I uranium mine.

The URF is used for the conducting of research, development and demonstration activities associated with the development of the future Czech DGR. Underground research laboratories play a vital role in the DGR preparation process worldwide. They are used, for example, for the development of methodologies applied to describe the rock environment and for obtaining data for the testing of mathematical models that demonstrate the safety of the DGR concept. Such laboratories provide for the conducting of in-situ experiments concerned with the development, behaviour and optimisation of the various components of deep geological repositories. Since 2017, most of SÚRAO's research activities involving in-situ experiments have been performed at the Bukov URF.

Phases of the Bukov URF development project:

1

Construction and characterisation of Bukov URF I (2013–2017)

The first section of the laboratory complex (Bukov URF I) is located on the 12th level of the mine complex near to the B-1 shaft. The excavation of the laboratory spaces commenced in 2013, and the operational phase began in 2017. The laboratory complex contains a total of 475 metres of corridors intended for experimental use. Even during the construction phase, an extensive **project** was conducted on the geological and geotechnical characterisation of the rock environment, the aims of which were to provide the detailed description of the rocks necessary for the positioning of the experiments and to obtain unique data on the impacts of the opening of the rock mass via excavation.

2

Experimental programme (since 2017)

The experimental programme covers a wide range of activities that are essential in terms of the Czech DGR development programme. The results of the experimental work will, for example, serve as the basis for the assessment of the rock mass and the behaviour of processes at the intended depth of the DGR with concern to both technical feasibility and safety. The research programme was divided into seven areas referred to as research and experimental plans (REP), as described in detail below.

3

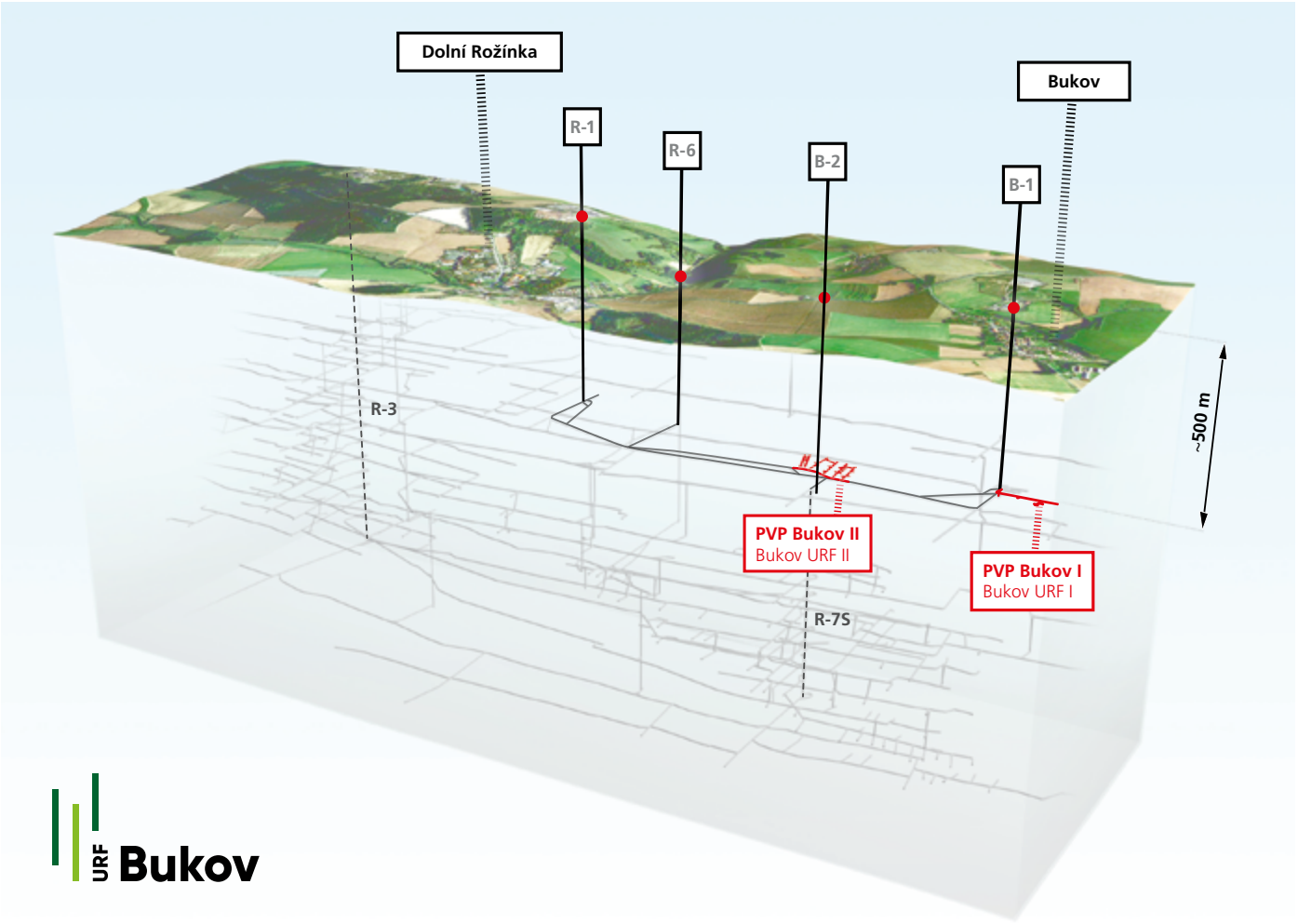
Reconfiguration of the mine (2020–2022)

Up to 2020, the mine infrastructure was operated much as it was during the operational phase of the mine. The modifications subsequently made were aimed at limiting the extent of the operational mine workings to those required for the operation of the laboratory complex. The number of operational shafts was reduced from 6 to 4 and the flooding of the lower levels of the mine complex (levels 13–24) was initiated. The modification work included, for example, changing the mine water pumping system, replacing certain discharge lines, reconstructing the transformer station, changes to the ventilation system and the modification of the building above the B-1 shaft.

4

Construction and characterisation of Bukov URF II (2021–2025)

The second part of the laboratory – Bukov URF II – is located near to the B-2 and R-7S shafts. It comprises a total of 6 laboratory corridors, each up to 95 metres long, 2 connecting ventilation corridors and a total of 13 test chambers of lengths of tens of metres. The laboratory complex was completed in April 2024. All the excavation work was conducted using the contour blasting technique. In a similar way to Bukov URF I, the excavation work was accompanied by a characterisation programme. The laboratory complex construction project simulated to the greatest extent possible the excavation of the disposal corridors in the future Czech deep geological repository (DGR), which provided invaluable information and experience that will be used in the future. The installation of the equipment will be completed in 2025, following which the new workplace will be put into operation.



REP1: The characterisation and creation of geoscientific models of the rock environment.

This area includes research aimed at collecting descriptive geological data, its storage in the relevant databases and its interpretation in the form of 3D models. **The Deep Horizons project** (2017–2020) was concluded in 2020. The purpose of the project was to obtain spatial geological data from the 12th to 24th levels of the Rožná I mine. The related laboratory and in-situ work focused primarily on the development of the geotechnical parameters of the rock mass with depth, the characteristics of the fractured zones around the underground corridors (EDZ) and the definition and detailed description of the homogeneous rock blocks present. A study of the so-called "first zone" of the mine made up a significant part of the project. In 2025, the four-year **Characterisation II (2021–2025) project** was completed; the aim of the project was to provide a geological description and the creation of a model of a rock block located in the Bukov URF II area. The input information was provided by core drilling, data obtained from the mapping of the excavated corridors and the application of geophysical research methods, e.g. seismic and electrical resistivity tomography, in both boreholes and along the walls of the corridors.

REP2: The long-term monitoring of the rock environment.

This REP includes, for example, the monitoring of the development of microbial settlements, the parameters of the groundwater and the movements of brittle structures. It further includes projects concerned with the development of geophysical methods. Ongoing and completed projects in this research area include:

→ **Microbial monitoring (2017–2019, 2020–2021)**
These two follow-up projects addressed the topic of microbial settlement in Bukov URF I and its wider surroundings. The research of microbial settlement continues in the context of other in-situ experiments (e.g. the Corrosion and Interaction experiments).

→ **Hydrogeological and hydrochemical monitoring (2018–2023, 2023–2024)**
These projects concerned the monitoring of, for example, changes in the groundwater chemistry and inflow rates to the underground corridors. A project is currently being prepared involving the expansion of the underground monitoring network to include the Bukov URF II area.

→ **Monitoring of brittle structures (2018–2022)**
The aim was to obtain knowledge on the movements of brittle structures in crystalline rocks at the depth of the future Czech DGR. For the purposes of this project, a monitoring network was installed in Bukov URF I with TM-71 extensometers for the provision of time-series data on the behaviour of various generations of brittle tectonic structures (fractures, faults).

→ **Development of geophysical methods (2018–2022)**
The project involved the development and testing of a system of electrical resistivity tomography instruments and seismic methods. The installed equipment allowed for the long-term monitoring of changes in the properties of the rock mass in the immediate vicinity of the underground workings.

→ **Temperature monitoring (2021–2030)**
The project involves the monitoring of the temperature parameters of the rock mass via an extensive network of boreholes that have been equipped with temperature sensors. The measuring stations are located in corridors on level 12 of both the Bukov URF I and II areas, as well as on certain higher levels of the mine.

→ **Stress monitoring (2023–2027)**
The project includes the acquisition of data and the evaluation of the stress in the rock mass in the URF II area via the application of methods applied in the past in URF I and other parts of the mine complex (convergence measurements and the related inverse analysis, methods for the measurement of deformations in boreholes with conical strain gauges, the hydraulic fracturing of borehole walls).

→ **Pore pressure monitoring (2024–2027)**
The purpose of the project is to obtain data on the development of the pore water pressure in the rock mass in the vicinity of selected excavated passages in the URF II area for the purpose of the mathematical modelling

of the damaged and influenced areas (EDZ and EIZ) of the rock mass in the vicinity of the excavated corridors.

REP3: Groundwater flow and the transport of radionuclides.

This area included **the Fracture connectivity project** (2019–2024), the aim of which was to improve the understanding of the advective transport of substances in the fracture systems of crystalline rocks. The project involved the creation of a network of experimental boreholes in a selected rock block for the conducting of hydraulic and tracer tests. All the tests were accompanied by modelling work aimed at creating and refining a geological and hydrogeological model of the rock block of interest for both the development of modelling tools and the simulation of the tests performed.

REP4: DGR engineered barriers.

This research area is concerned with the development and verification of the characteristics of the materials of the waste disposal package and the sealing and filling materials. The main aim is to determine the rates of the degradation of the various materials and their mutual interactions under real DGR conditions. For example, **the Interaction experiment** (2017–2027) is concerned with the study of interactions between the DGR engineered barrier materials and their further interaction with the rock environment and the groundwater. The experiment consists of several physical models that have been emplaced in the rock mass, which allows for the study of interactions at both the ambient temperature and at elevated temperatures of up to 200°C. **The Corrosion experiment** (2021–2034) is addressing the key issue of the determination of the corrosion rates of candidate materials for the construction of the waste disposal package. The research involves the embedding of samples of the various materials in a layer of bentonite that makes up one of the components of a series of physical models emplaced in boreholes. The experimental site consists of a total of 10 boreholes in which the physical models have been embedded.

REP5: Impacts of the construction of the underground structures of the DGR on the rock environment.

A pilot project in this area was conducted in the Bukov URF as early as during the construction of Bukov URF I (2015–2018). Additional information on the characterisation of EDZ and EIZ was provided by the results of projects that focused on the development of geophysical methods and **the Characterisation II project** (2021–2025).

REP6: Technological procedures for the construction of the DGR.

The construction of the DGR will require the application of certain technological procedures not commonly used in standard commercial excavation projects, including, for example, special disconnection and drilling work. The Contour blasting project (2023–2024) made a significant contribution to the research in this area. The project involved the testing of various drilling approaches and blasting methods in selected test chambers in Bukov URF II.

REP7: Demonstration experiments.

Such experiments are concerned with the testing of handling technologies, the construction of experimental models and the monitoring of processes. Bukov URF II will be used for the conducting of such experiments.

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