The Bukov Underground Research Facility as Part of the Czech Republic's DGR Development Programme – 15644

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ABSTRACT

The Czech Republic's deep geological repository (DGR) policy sets out a number of important milestones including the selection of candidate sites by 2018 and the selection of a final site by 2025. The final commissioning of the Czech DGR is planned for 2065. In 2010 a screening process was completed employing geological and other criteria that resulted in the identification of 7 potentially suitable sites, all situated in crystalline – granite host rock environments. The next step of the process will result in a reduction both in the number of sites and the surface area of remaining sites based on preliminary safety evaluations and socioeconomic, political and environmental criteria. In order to better understand the behaviour of crystalline host rock environments for DGR safety case purposes, the Radioactive Waste Repository Authority (RAWRA) made decided to enhance the extent of in-situ measurements and research at a depth corresponding to that of the future DGR. In the second half of 2013, RAWRA commenced the construction of the Bukov Underground Research Facility (Bukov URF) in the southern section of the Rožná uranium mine at a depth of 600m below the earth's surface in a geologically well-mapped area of a Moldanubic crystalline rock formation which is composed principally of migmatised gneisses, migmatites and granulites. The Bukov URF will be, first and foremost, a research facility at which work will be conducted focusing on the taking of geophysical measurements, petrographical, mineralogical, geochemical research and the in-situ determination of the physical – mechanical, geochemical and hydrogeological properties of the host rock massif. The research results will form input data which will be used to both support and improve the safety of the future DGR.

INTRODUCTION

The Czech Republic's deep geological repository (DGR) policy sets out a number of important milestones including the selection of candidate sites by 2018 and the selection of a final site by 2025. The final commissioning of the Czech DGR is planned for 2065. In 2010 a screening process was completed employing geological and other criteria that resulted in the identification of 7 potentially suitable sites, all situated in crystalline – granite host rock environments. The next step of the process will result in a reduction both in the number of sites and the surface area of remaining sites based on preliminary safety evaluations and socioeconomic, political and environmental criteria.

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The main objective of the project is the characterisation of the local rock mass at depths of 500–900m below the earth's surface in crystalline rock which makes up part of the Bohemian Massif for the needs of research into the siting of a repository for radioactive waste (DGR) in the Czech Republic. Work at the

Bukov URF over the next few years will involve the fields of geology, hydrogeology and geotechnics. It is hoped that the research will assist in obtaining detailed knowledge regarding the use of rock environment characterisation methods for the disposal of spent nuclear fuel and high-level waste at depths corresponding to those envisaged for the construction of the DGR. The design of the facility is intended to simulate as much as possible the environment of the future DGR and was inspired by the construction of underground laboratories in crystalline rock in Aspo, Sweden [1] and Grimsel, Switzerland [2]. The final design fully respects current requirements in terms of geometry and the volume of excavation set out in the Updating of the Reference Design [5].

BUKOV URF LOCATION

A site close to the Bukov (B1) Shaft in the cadastral district of the village of Bukov near Žďár nad Sázavou in the Vysočina region was selected for the construction of the underground research facility. The site is located in the southern section of the Rožná uranium deposit some 300m from the Bukov mine at level 12 around 520m beneath the earth's surface. The Bukov site offers a wide range of options in terms of the detailed study of hydrogeological, geological, geotechnical and geochemical conditions in connection with deep geological nuclear waste disposal. A significant advantage of the site lies in there being no unsolved fundamental conflicts of interest since the mining complex has one clearly defined owner who is authorised to conduct mining activities. The facility is being constructed in the Rožna working district (see Fig. 1) which is close to one of the localities being considered for the potential construction of the Czech DGR (the Kravi Hora locality). A large number of research projects have already been conducted at this locality (geological mapping, surface geophysics, hydrogeological investigation). Importantly, it is possible at this location to verify data obtained from the surface by testing at real repository depth (several hundred meters below the surface). In addition, the entire Rožna mine complex has been granted the status of a controlled zone for working in an environment with ionising radiation, including the underground research facility. Therefore, it will be possible to conduct transport experiments focusing on radionuclide migration and sorption.

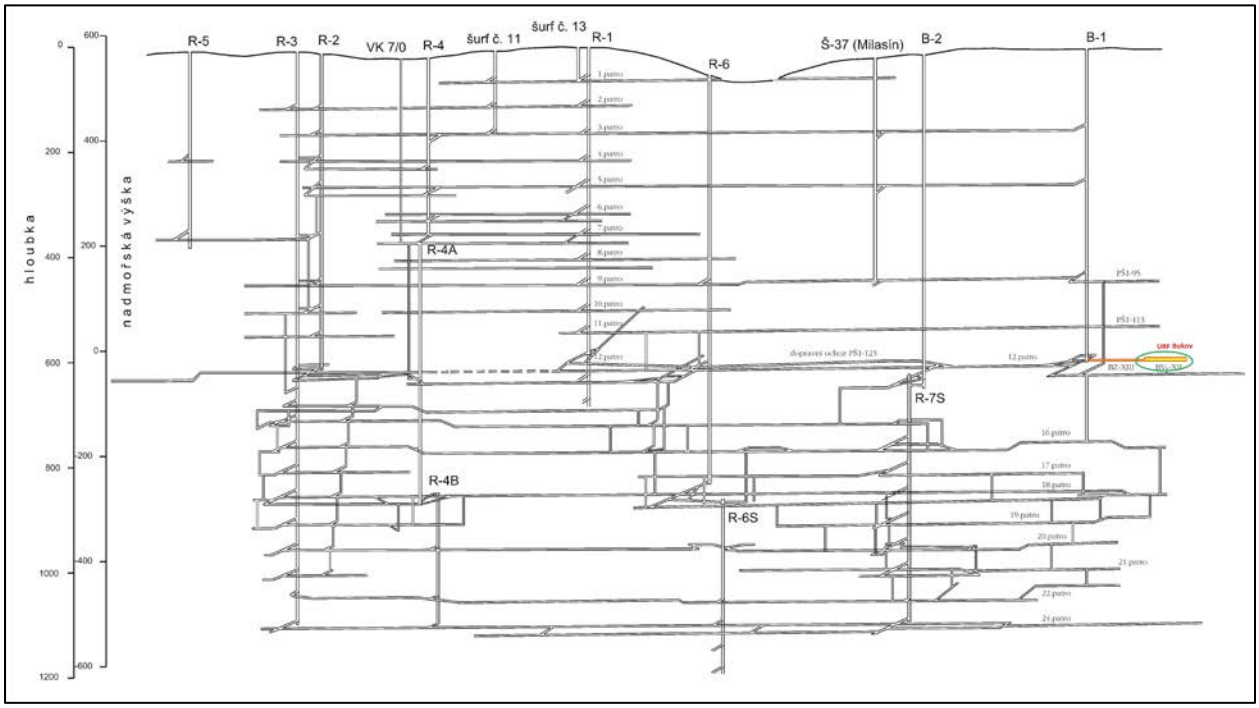

Fig. 1. Chart showing the Rožna U mine complex and the location of the Bukov URF

TECHNICAL DESIGN

The technical design of the underground facility was drawn up, in compliance with the requirements of the State Office for Nuclear Safety (SUJB), to suit the requirements of future research activities, primarily with regard to the smoothest possible excavation techniques with the smallest excavation disturbed zone (EDZ) possible, which will be conducted at the facility once the initial excavation work is completed. The underground area consists of a 300m long connecting cross gallery with a profile of 9.2m^2 leading from the Bukov entrance shaft at level 12, 600m below the surface (see Fig. 2), and the underground facility itself which consists of a 45m long large-profile chamber with a cross-sectional area of 29.7m^2 and a system of gallery niches with a total length of 35m and a profile of 9.2m^2 (see Fig. 3). In addition, a number of drilling and laboratory chambers are regularly distributed throughout the underground complex. Rock bolts will be used to provide support for the underground sections with yieldable TH arches in areas with more complicated geological conditions. A shovel loader was designed for the loading of excavated material on to JDV 0.65m^3 vehicles. The transport of the material was by rail vehicles to shaft B1 or shaft R1 at level 12 from where the JDV vehicles removed the material to the surface via the access shafts. Ventilation is provided by a separate combined system which operates via the main ventilation duct.

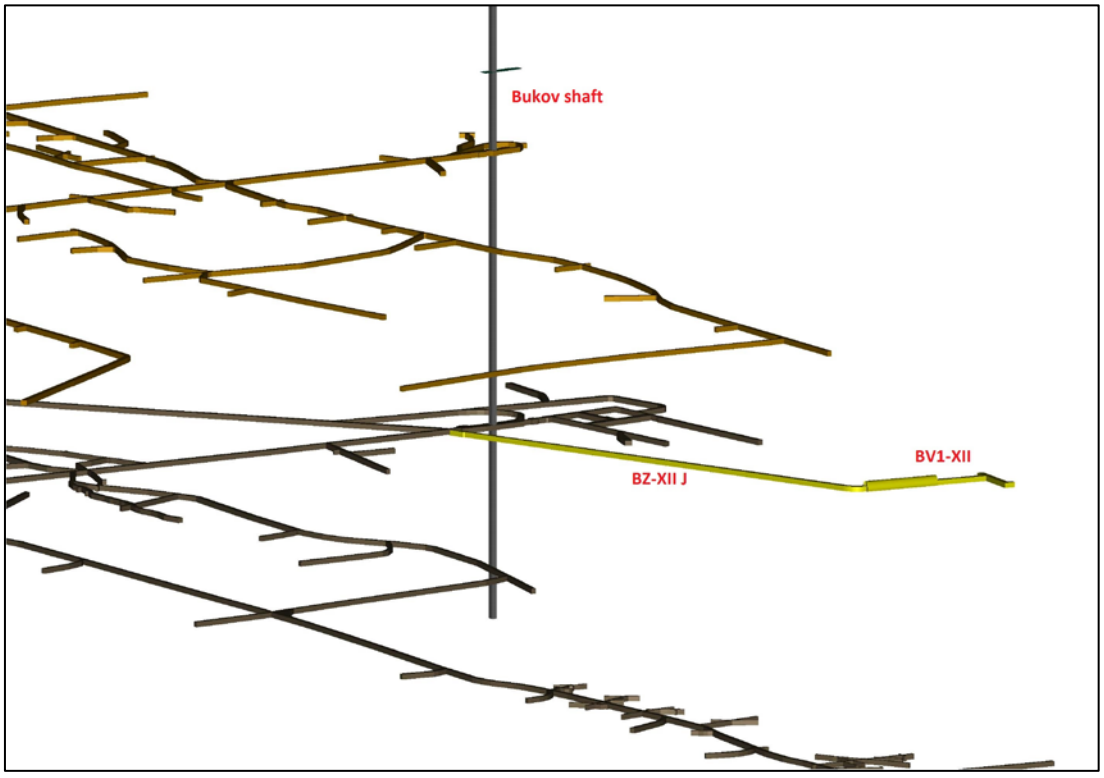

Fig. 2: Detail of the location of the Bukov URF in relation to the Bukov mine shaft

CURRENT PROGRESS OF EXCAVATION

Preparation work commenced in June 2013 at which time the transport route between the R-7S shaft of the Rožna Mine and the Bukov (B1) shaft was renewed involving the replacement of rails and sleepers, the renewal of a drainage ditch and the replacement of a pressurised air pipeline and water distribution pipes. The cables and pipeline were relocated in the Bukov shaft at the future intersection with the cross gallery. Excavation work proper commenced in the middle of September with the blasting of cross gallery BZ-XIIJ (see Fig. 3). The initial 10m was excavated with a cross-section of 10.2m^2 and with steel supports. The excavation of the 140m connecting cross gallery BZ-XIIJ was completed at the end of 2013. The section between measurement points 10m and 140m has an excavated cross-sectional profile of 9.2m^2. Steel arches with crowns and sides braced with corrugated metal sheets or expanded metal were installed up to measurement point 108m. The empty spaces were filled with round timber. From measurement point 108m to point 250m, rock bolt supports with crowns were installed with some parts braced with expanded metal or mesh; steel arches were fitted in areas with complicated geological conditions (e.g. the mylonite weakness zone).

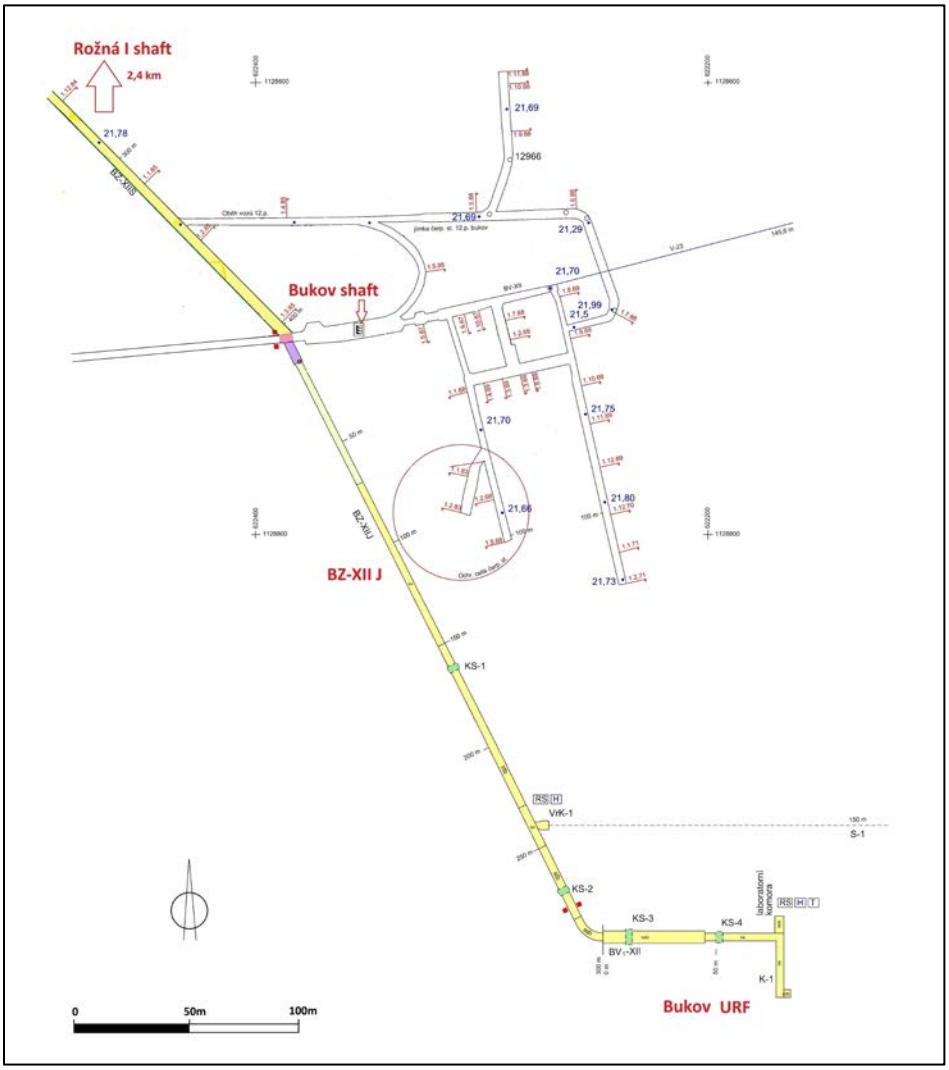

Fig. 3: Bukov URF – detail of the design of the facility

Drilling chamber VrK1 will be excavated at measurement point 240m of connecting cross gallery Z-XIIJ. A 150m long-cored hole, 76mm in diameter, will be bored from the chamber perpendicular to the relevant anticipated geological structures the purpose of which will be to provide detailed information on the geological situation in the contact zone between amphibolites and migmatitised biotitic schist. A second 76mm-diameter hole will be drilled into the excavation face at the 250m measurement point in the direction of the cross gallery with a length of 60m and, subsequently, a third hole, 100m long, will be drilled in the direction of the underground research complex at the 300m measurement point. Subsequent work at the facility will be refined in detail on the basis of the three drilling operations.

RESEARCH WORK

The Bukov URF is, first and foremost, a research facility at which work will be conducted focusing on the taking of geophysical measurements, petrographic research, mineralogical research, geochemical work,

the in-situ determination of the physical-mechanical properties of rocks, drilling for micro seismic research purposes, field testing and geotechnical research. The results will form input material for further work concerning the confirmation of the safety of a future deep geological repository.

The initial scientific programme is focused on the characterisation of the site from the geological, geomechanical and hydrogeological points of view. The results will serve as input data for the building of synthetic geosphere models which, in turn, will serve for the precise determination of the location of the various elements of the experimental programme. The characterisation programme includes the following research areas:

1. *Complex geological characterisation*

The application of a range of geological methods will be aimed at producing a multidisciplinary description of the host rock in order to determine the best locations for conducting the experimental programme. Geological characterisation will comprise geological and structural mapping and the deciphering of the temporal, spatial and thermal evolution of the ductile and brittle pattern. Further, more detailed, characterisation will focus on the conducting of specialised studies e.g. the radiometric dating of the fault system and the identification of microfractures in the rock.

2. *Geotechnics*

The geotechnical programme will comprise a total of three areas: (i) stress monitoring, (ii) geotechnical laboratory testing and (iii) seismic monitoring. Stress measurement will allow for 3D stress tensor estimation and the prediction of both the stability of the rock mass and stress changes brought about during excavation. Laboratory geotechnical testing will comprise a range of methods that will serve for initial rock mass characterisation and input data for further geotechnical modelling. Seismic monitoring will cover the potential reactivation of the fault system during blasting and possible induced seismic activity caused by ongoing mining operations in the vicinity of the underground facility.

3. *Drill core analysis*

It is intended that the drill core analysis programme will serve for the development and testing of drilling technology to be employed in the DGR investigation deep-borehole drilling programme planned for 2017; optical scanner and hyperspectral analysis methods will be applied.

4. *Transport properties of the rock*

The study of the transport properties of the rock massif will serve for the laboratory testing of potential radionuclide sorption and migration from repository depth.

5. *Hydrogeological properties of the rock mass*

An understanding of the behaviour of water within the repository system is crucial in terms of the safety case. Hydrogeological studies will include the monitoring of the evolution of the chemical and physical properties of the rock and the monitoring of water influx [3]. Borehole hydrogeological measurements, tracer tests and water pressure tests will be conducted during the subsequent experimental phase [6].

CONCLUSION

The construction of the Bukov Underground Research Facility is fundamental in terms of the characterisation of rock masses intended for the location of a future radioactive waste repository in the Czech Republic. The facility is ideally located for this purpose, i.e. it is 520m beneath the earth's surface in a crystalline rock environment. The research that will be conducted at the facility will make a significant contribution to a more detailed understanding of the processes that will take place within the repository over its lifetime.

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