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Geotechnical Characterization of Bukov Underground Research Facility

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Abstract

Bukov Underground Research Facility (Bukov URF) is designed to operate as a test site to assess the properties and behavior of the rock mass analogous to selected seven candidate sites in the Czech Republic. It is situated at a depth of about 600 m beneath Earth´s surface, which corresponds with the proposed storage depth of the final locality for the national deep repository of high-level radioactive waste. Bukov URF, the construction of which has started in 2013, is situated in the southern part of the Rožná uranium deposit, about 40 km NNW from Brno. The rock mass is composed of relatively monotonous rock sequences mainly represented by migmatized biotite paragneisses up to stromatic migmatites, amphibole-biotite to biotite-amphibole gneisses, and amphibolites. Based on the analysis of physical and mechanical properties, intact rocks in the studied area exhibit a high to very high strength and may be only locally affected by metasomatic alterations. The research activities focus on a complex geological and geotechnical characterization of the rock mass of interest, which is necessary for further in situ research. This paper briefly describes the main results of the current stage of geotechnical exploration and research works made there by the Institute of Geonics of the CAS. These works especially include: determination and evaluation of physical and mechanical properties of the rocks taken from the drift walls and from the boreholes during driving, calculation of rock mass quality based on selected index rock mass classification systems, determination of stress and strain state of the rock mass using the methods of hydrofracturing, Goodman Jack, strain gauge probe measurements, long-term periodical tensometric and convergence measurements, and evaluation of the effects of technical and mining-induced seismicity on the rock mass of interest.

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Keywords: Bukov URF; Underground Research Laboratory; deep geological repository; nuclear waste; geotechnical monitoring; rock mass quality; physical and mechanical properties; stress measurements

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1. Introduction

The disposal of spent nuclear fuel from operation of power generation and research reactors, and waste produced after its reprocessing, in deep geological repositories (DGRs) is considered, not only in Europe but also in other developed parts of the world (the USA, Canada, Japan, South Korea, Russia) to be by far the safest way of rendering such waste harmless. To check the properties of the host rock environment and to carry out a large number of research activities linked with the future DGRs, underground research laboratories (URL) are gradually being built in many countries around the world since the early 1980s. These URL are mainly situated either in crystalline rocks (e.g. AECL URL in Canada, Äspö Hard Rock Laboratory in Sweden, ONKALO underground research facility in Finland or Grimsel Test Site in Switzerland) or in clayey sediments, such as HADES URL in Belgium, Mont Terri URL in Switzerland, and Bure URL in France.

The disposal strategy for heat-generating nuclear waste in the Czech Republic assumes the construction of a deep geological repository in crystalline host rocks (granitoids and/or migmatites) at a depth of 500 metres [1]. That is why the generic research program focused on the detailed testing of the crystalline rock concept was initiated in the Czech Republic over the past few years. Bukov Underground Research Facility (hereinafter referred to as Bukov URF) represents a crucial part of this underground generic research program. Construction phase of Bukov URF was started in 2013 and terminated during 2016. In 2015 and 2016 the characterization program of Bukov URF was simultaneously carried out. This initial scientific program was aimed at the characterization of the site, in particular from the geological, geomechanical, geotechnical, and hydrogeological points of view. The obtained results will serve as input information for various experiments included in the research program running between 2016 and 2025 [1]. In this context, the paper presents the main knowledge gained so far in the field of geotechnical and geomechanical characterization of Bukov URF.

2. Regional geological situation and geological conditions of Bukov URF

Bukov URF is situated in the Vysočina Region near Kraví Hora candidate repository site and adjacent to Rožná I uranium mine, approx. 3 km south-eastwards from the municipality of Dolní Rožínka. The underground research laboratory is located on the level 12 of the Bukov-1 shaft at the depth of about 600 meters below the Earth's surface. Bukov URF consist of ca 300-metre-long, NW-SE striking, access gallery BZ-XIIJ with a profile of 9.2 m^2 leading from the Bukov-1 shaft, and 25 m long, westward driven testing drift ZK-1 (0-10 m in profile 9.2 m^2, 10-25 m in profile 14.2 m^2), and finally 90-m-long, E-W trending, main facility BZ_1-XII (0-40 m in profile 9.2 m^2, 40-90 m in profile 14.2 m^2). From that main facility three experimental niches with profile of 14.2 m^2 and with length between 10 m and 20 m were driven in the northern and southern direction, respectively.

As for the regional geology, Bukov URL is found at the southern part of the Rožná uranium deposit, at the north-eastern edge of the Strážek Moldanubicum close to its contact with the Svratka Unit. The Strážek Moldanubicum (Fig. 1) consists of high-grade metamorphosed rocks with polyphase Variscan tectonometamorphic development. The petrography is characteristic of dominant biotitic, cordierite-biotitic and amphibole-biotitic paragneisses, affected by varying degrees of migmatization and transitioning into stromatic to oftalmitic migmatites in places. The prevailing rocks contain layers of variegated rock intercalations - amphibolites, skarns, calc-silicate rocks, and crystalline dolomitic limestone. Less abundant are felsic granulites and granulitic gneisses accompanied by tectonically incorporated bodies (boudins) of upper-mantle garnet pyroxenites, garnet- and spinel peridotites, serpentinites and eclogites. The rocks of the Strážek Moldanubicum are in places penetrated by small, post-tectonic bodies of gabbros, ultrapotassic melanocratic granites to syenites (durbachites), and two-mica granite [2, 3]. From the tectonic point of view, two basic generations of superimposed ductile tectonometamorphic structures can be distinguished in the Strážek Moldanubicum. The relatively older, subvertical foliation of ~NNE–SSW to N-S direction was subsequently refolded and refoliated into new flat-laying foliation planes with regional NW-SE to WNW-ESE strike. These younger foliation planes generally gently dipping towards S to SW. After the formation of ductile structures comes the formation and polyphase reactivation of a heterogeneous set of brittle-ductile and brittle structures (fault zones, shear and tensile joints) of NW-SE, WNW-ESE, NNE-SSW, and N-S orientation [3, 4].

The space of Bukov URL is composed of a relatively monotonous complex of metamorphic rocks. The complex is represented by a differently migmatized petrographic sequence starting with biotite gneisses and migmatites,