

RESEARCH, DEVELOPMENT AND DEMONSTRATION PROJECTS AT THE JOSEF UNDERGROUND LABORATORY

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Abstract. The Centre of Experimental Geotechnics (CEG), the department of the Faculty of Civil Engineering, Czech Technical University in Prague, is a full member of the Underground Research Facility Network for Geological Disposal (IAEA, URF Network). The main role of the URF Network is to establish a community for sharing experience and learning in the field of the geological disposal of radioactive waste. The CEG operates the Josef Underground Laboratory, and the extensive underground laboratory space available at this facility provides a unique background for experimental research, education, training and demonstration activities relating to the geological disposal of radioactive waste. Although the Josef facility is not intended for waste disposal, it does play a very important role in terms of the early stage of the site selection process for the Czech deep geological repository.

The Expert Cooperation in the Construction of the first Czech Underground Migration Laboratory with the Potential Application of Active Tracers project makes up one of the most important research projects currently underway at the Josef facility. The objective is to obtain the knowledge from foreign partners necessary for putting the first in-situ underground laboratory with the potential application of active tracers into operation in the Czech Republic. As such research has not yet been conducted in the Czech Republic, it was essential to engage the involvement of foreign specialists. The participation of Swiss experts from the NAGRA organisation allows both the design and subsequent implementation of the experimental programme at the Josef facility's laboratories in such a way that the research and training processes are effective and so as to avoid the repetition of outdated experimental procedures and research topics. The ongoing Mock-up Josef experiment, which consists of an in-situ physical model simulating the vertical emplacement of a container with spent nuclear fuel, provides a further example of one of the more important experiments underway at the facility. The in-situ experiment involves research into the effects of heat and groundwater on the bentonite buffer surrounding a heater which simulates a spent nuclear fuel container emplaced in an underground repository.

This article provides information on the Josef Underground Laboratory and its rich history of RD & D projects concerning the development of the Czech deep geological repository.

Key Words: Josef Underground Laboratory, geological disposal, migration laboratory, Mock-up Josef

1. Introduction

The Centre of Experimental Geotechnics (CEG) represents one of the most unique departments at the Faculty of Civil Engineering, CTU in Prague. In addition to providing teaching courses, mainly of a practical nature, in the field of geotechnics, it also specialises in the conducting of complex RD&D projects. One of the research facility's most important roles is to provide practical in-situ instruction in the fields of geotechnical engineering, geology, geochemistry, radiochemistry and radioecology. The training of future experts in this authentic underground setting also frequently involves the participation of other Czech universities and experienced specialists from outside the academic sphere. The IAEA (International Atomic Energy Agency) has added the CEG to its prestigious list of international training centres. In addition to teaching and training, the CEG is heavily involved in a wide range of research and development activities; indeed, the Josef Underground Laboratory, operated by the CEG, is currently being used for research purposes

in connection with a number of European Union-supported international experimental projects addressing a wide range of issues related to deep repository radioactive waste disposal (TIMODAZ - FP6, FORGE - FP7, PETRUS II - FP7, DOPAS, etc.) as well as several domestic projects (Mock-up Josef, etc.) supported by the Czech Ministry of Industry and Trade, the Czech Science Foundation and the Czech Radioactive Waste Repository Authority (SURA).

2. Research, Development and Demonstration Projects

The Josef Underground Laboratory offers more than 5km of a total of 8km of galleries (driven during the investigation of the Mokrsko – Čelina gold deposits in the period 1981 – 1993) for teaching and research purposes. No less than seven international and domestic research projects are currently underway at the Josef facility and a further four projects are in the preparation stage. Whilst the CEG is gradually extending the range of research and educational activities into other scientific fields, the main theme of both research projects and educational courses involves issues concerning the safe disposal of spent nuclear fuel in deep geological repositories including research into migration processes underway in real rock environments currently being conducted by the CEG in cooperation principally with the Nuclear Research Institute - Řež (ÚJV Řež), but also including a number of other partner institutions.

Since the first section (Čelina West) of the Josef underground complex of galleries, with a total length of 650m (Fig. 1), was opened for educational and research purposes in 2007, the total length of reconstructed galleries has been gradually extended to over 5km (Čelina West, Čelina East and Mokrsko West). The granitic rock complex (the Mokrsko West section) has been equipped with core-forced air ventilation, a power distribution network, water supply systems and a high-speed internet optical cable network. The various core distribution systems installed at the facility will serve for the connection of the niche selected for the construction of the migration laboratory for research involving the application of active tracers.

In 2010, the first student laboratory for teaching in the field of the disposal of hazardous substances and gases was constructed in the granitic rock medium section of the underground complex. In 2013, the CEG FCE CTU opened a migration laboratory for research involving non-active tracers in the Čelina West underground section (in the vicinity of the entry portals to the underground complex). The migration laboratory was built as part of the TA CR Determination of the Migration Parameters of Minerals with Fissure Permeability using Fluorescent Solutions project. Clearly, therefore, the CEG has extensive experience in terms of the reconstruction of underground galleries for the needs of specialised laboratories.

In 2011, the CEG opened a new facility within the Josef complex – the Josef Regional Underground Research Centre (Josef URC) which involved the complete reconstruction of a surface building to include an experimental hall, laboratories and other support facilities. This building provides the necessary backup services for the experimental research conducted in the underground complex.



FIG 1. – Horizontal layout of the Josef Underground Laboratory (left) and pictures of the entrance to the underground complex; the upper-right picture shows the entrance to the underground complex prior to reconstruction in 2006; the lower-right picture shows the entrance portals today

At the beginning of 2013, the CEG submitted the Inter University Laboratory for the In-situ Teaching of Transport Processes in a Real Rock Environment development project for approval to the Ministry of Education, Youth and Sport of the Czech Republic; the co-researcher consists of ICT Prague.

In December 2013, together with a number of research partners (with ÚJV Řež as the senior researcher), the CEG applied to the Technology Agency of the Czech Republic (TA CR) to conduct the PAMIRE project (Transfer of Granitic Rock Parameters from the Micro Scale to the Real Rock Massif Scale).

However, since neither of the above projects provide for financial support for the participation of foreign experts, the CEG subsequently decided to apply for a grant from the Partnership Fund of the Swiss-Czech cooperation programme. Consequently, a new project entitled Expert Cooperation in the Construction of the first Czech Underground Migration Laboratory with the Potential for the Application of Active Tracers commenced in 2014. Up to this time, research into migration processes in the real environment of an underground laboratory using active tracers was allowed at just two other European facilities – SKB, Sweden and NAGRA, Switzerland. Importantly, the CEG (and ÚJV Řež) has enjoyed extensive cooperation with both these facilities in the past in the context of the EU FP6 and FP7 (Euratom) research projects. It is generally recognised that the Swiss organisation NAGRA, which runs the Grimsel Test Site (GTS) underground laboratory, employs the most experienced experts in the field of migration research. Therefore, the objective of the project, which will include consultation with Swiss experts, mutual visits and a series of bilateral workshops, is to obtain the knowledge necessary for putting into operation the Czech Republic's first in-situ underground laboratory with the potential for the application of active tracers.

3. Mock-up Josef Experiment

Since the geological disposal of high-level radioactive waste is based on the multi-barrier concept, including the use of bentonite, the Centre of Experimental Geotechnics decided to construct the first Czech in-situ mock-up model of a disposal place employing a bentonite barrier. The experimental model, named Mock-up Josef, enjoys the active support of the Czech Radioactive Waste Repository Authority (SURA). The project, which commenced in 2012, was planned to run for four years, i.e. to 2016 or up to the time the bentonite in the model reached full saturation. The physical model, which is situated in the Josef Underground Laboratory, is being loaded with underground water and features a heater which simulates the heat produced by the container with spent nuclear fuel enclosed by the bentonite layer. The model consists of a barrier made up of bentonite blocks, a heater, a comprehensive monitoring system and stainless steel construction equipment. The model was constructed in the Josef surface laboratory and subsequently transported to the selected niche in the Josef underground complex. The model was placed within a vertical disposal hole with a diameter of 750mm and a depth of 2500mm in December 2012. The experiment is located in the granitic section of the Josef facility (the Czech DGR development programme assumes that the future DGR will be constructed in granite host rock).

4. Conclusions

Cooperation with international institutions provides an effective way in which to advance the Czech geological disposal of high-level radioactive waste programme. The complex research, development and demonstration projects conducted at the Josef facility provide information, experience and important data relating to the various components of the disposal system.

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