Underground research laboratory (URL) for geological disposal of radioactive waste and possibility for construction in Bulgaria

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Abstract. The construction of an underground research laboratory (URL) precedes the construction of a repository for geological disposal of a radioactive waste. The article considers the types of laboratories, their main objectives and tasks. Based on a comparative analysis between the sites selected as prospective for geological disposal in Bulgaria, the Sumer site in the Sumer Formation is proposed for further investigation as an alternative for URL construction.

Keywords: underground research laboratory, radioactive waste, Sumer Formation, marls, Bulgaria.

Introduction

The construction of an underground research laboratory (URL) is a very important part of the activities, proving that a given geoenvironment is appropriate for high level waste (HLW) geological disposal. The site selection analyses for deep geological disposal in Bulgaria have brought to the conclusion that the potential host rocks in Bulgaria are the clayey marls of the Sumer (K₁s), Trambesh (K₂s), and Gorna Oryahovitsa (K₃) Formations. The Sumer Formation is a relatively thick (up to 1200 m) sedimentary succession distinguished in the western part of the Fore-Balkan Unit (NW Bulgaria). The new data about the composition, physical and sorption properties at depths of 200 and 400 m substantiate its lithological homogeneity (Tsvetkova, 2021).

This article is aiming to introduce an idea about the possibilities of building a URL in the Sumer Formation.

Underground research laboratory – main objectives and tasks

Geological repository program takes place over a period of decades, which requires an adaptive and flexible approach to the choice of changing technologies, as well as to public and political attitudes. This long process generally continues in stages, each of them involving different activities.

The construction of the geological repository and URL must be well justified and planned in time with the objective of consecutive and continuous implementation without loss of human and financial resources. For example, the building of the French Bure laboratory amounted to 280 million EUR as of 2010 and the operational research and development program, including the exploitation resources cost around 60 million EUR per year (NEA, 2013).

URL is an indivisible part of any geological repository, which is necessary to confirm the qualities of the selected geological environment and to increase the confidence of the interaction between various stakeholders and interested public. The main objective of the activities in URL is to prove the safety of HLW geological repository.

There are two types of URL (Nuclear Energy Agency, 2013) – for general (Generic) and detailed (Site-specific) investigations, respectively. The first type of laboratories intends to obtain more general information, necessary to confirm the choice of the host environment. Sometimes these laboratories
may be strategically developed, using pre-existing underground facilities. The laboratories for detailed research are built at the site intended for a waste disposal. The data obtained are necessary for the final design, construction, safety assessment and verification of the geoenvironment qualities.

The countries with already built URL are included in an international research program under the auspices of the IAEA and have an agreement on cooperation, information, specialist and experience exchange. There are two types of such laboratories – generic laboratories in Belgium, State of Nevada, Japan, South Korea etc., and site-specific laboratories in Germany, USA, France, Finland (a country, where the first HLW repository is expected), etc.

The underground laboratory can be built at the selected site of the potential repository, as well as in a similar to the rock formation of the site. In the cases when the geological environment is not finally selected, the URL can be built in two types of rock formations with the aim of detailed studies for the choice of one of them.

The URL plays an important role in the development of new technologies for HLW storage. Equipment is developed for them for tunneling and shaft drilling, for production and placement of buffer materials, testing machines for HLW containers (Fig. 1a, b) and their horizontal and vertical installation vehicle (MacKinno, 2015). An example of a new technology is the developed in the Los Alamos National Lab scaled-down prototype of an intended for waste canister (Fig. 1c), filled with a material reproducing canister (Fig. 1c), filled with a material reproducing canister (Fig. 1c), filled with a material reproducing canister (Fig. 1c), filled with a material reproducing canister (Fig. 1c), filled with a material reproducing canister (Fig. 1c), filled with a material reproducing canister (Fig. 1c), filled with a material reproducing canister (Fig. 1c), filled with a material reproducing canister (Fig. 1c), filled with a material reproducing canister (Fig. 1c), filled with a material reproducing canister (Fig. 1c), filled with a material reproducing canister (Fig. 1c), filled with a material reproducing canister (Fig. 1c), filled with a material reproducing canister (Fig. 1c), filled with a material reproducing canister (Fig. 1c), filled with a material reproducing canister (Fig. 1c), filled with a material 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logical and the Nuclear Research Institutes of the Bulgarian Academy of Sciences. A concept for a National RAW Repository was developed in the nineties followed by additional investigations (e.g., Evstatiev, Kozhoukharov, 1995, 1998, 2001).

As of the present, the site selection in the country has reached the second stage, and, using selection by sequential exclusion, five areas have been selected, with marl terrains in North Bulgaria being accepted as the most promising ones (Karastanev et al., 2011).

In 2021 the investigations in the Sumer Formation were expanded and supplemented and a comparative analysis of the three marl formations were made. The conclusion from this analytic study is that all three formations are characterized by a broad area distribution and relatively large thickness (the Sumer Formation – about 1200 m, the Trambesh Formation – about 500 m and the Gorna Oryahovitsa Formation – about 500 m) and in some places are embedded with other clayey formations. All three are represented by dense marls, more rarely siltstone, with thin sand interbeds. The composition of marl formations is relatively uniform and homogeneous. The three selected formations are sub-horizontal and are located in low-active tectonic zones, with favorable hydrogeological conditions and during the oil and gas explorations some of them have been accepted as aquitard layers.

The Sumer Formation is preferred due to its considerable thickness, spatial homogeneity, relative uniformity and favorable physical and sorption properties (Karastanev et al., 2011; Tsvetkova, 2021). It offers good possibilities for the construction of a deep repository and so far two promising sites have been localized in it – the Varbitsa and the Sumer site. The Varbitsa site is relatively well explored. It is suggested in the present publication to explore also the Sumer site for the construction of URL. This site is located in the vicinity of the homonymous village of Sumer (Fig. 2). The proximity of the two sites has many advantages, both in terms of logistics and from the viewpoint of marl properties.

The comparative analysis of the geological conditions and parameters of the marls of the Sumer Formation and similar argillites in France, Belgium and Switzerland, where URL have been built and operated, shows that they are more or less very similar (Tsvetkova, 2022). The results obtained from

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![Isopach map of the Sumer Formation](image_url)
the comparison will support the future exploration activities and the public acceptance of the geological disposal of HLW in Bulgaria.

Conclusion

The nuclear countries are required to dispose HLW on their territory and most probably this will happen in a geological repository. Before building the repository, investigations are carried out in an underground laboratory, for which at least two site variants are necessary. In Bulgaria, the Varbitsa site is considered so far as the most promising one for geological repository. There are also good conditions for an underground laboratory in the vicinity. The Sumer site is proposed as an alternative site for exploration after analyzing the international experience and the previous investigations in the country.

References


Tsvetkova, M. 2022. Comparison between the geological settings of the Varbitsa (NW Bulgaria) and Bure (SE France) sites for geological disposal of radioactive waste. – Geologica Balc., 51, 1, 57–65; https://doi.org/10.52321/GeolBalc.51.1.57.