Underground research laboratories in nuclear waste containment

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Introduction

The favoured long-term solution for the disposal of high-level radioactive waste generally involves the construction of deep geological repositories. The development of such facilities pose important challenges from the point of view of scientific understanding, rock exploration and engineering construction. A characteristic of this field is the existence of a significant number of Underground Research Laboratories (URLs). The key functions of URLs comprise the characterization of the host rock and the potential effects of excavation, the demonstration of the feasibility of construction and operation of the repository, and the enhancement of the understanding of the complex coupled phenomena that will take place in such an environment. A main advantage of URLs is that they allow the performance of research activities under conditions similar to those of the actual repository (NEA 2001, NEA 2013, IAEA 2001). Naturally, URLs are located in geological media thought to be suitable for repository implementation.

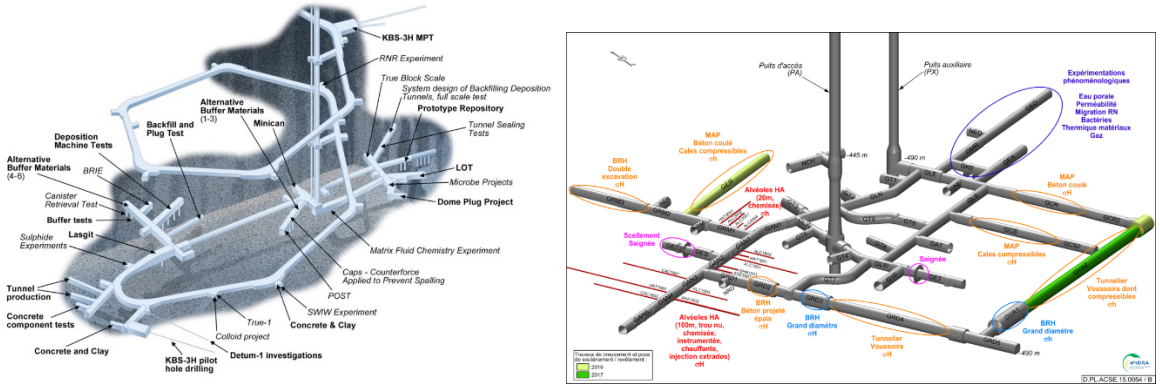
Underground Research laboratories: operating and discontinued facilities

The URLs can be classified in two basic categories: Generic and Site specific (Fig.1). Generic URLs are facilities that are located in sites that will not be used for waste disposal. Their role is to gain general experience in a particular rock type and to provide information that can be used to support waste disposal at other locations. Sometimes these facilities are developed taking advantage of existing excavations in the form of tunnels, drifts or mines. In contrast, site specific URLs are generally constructed ex-novo at locations that are considered as potential sites for waste disposal. They are located close or within the proposed disposal facility. In that case, it has to be ensured that the research activities carried out do not cause any undesirable effects to future disposal operations and do not affect adversely the eventual safety of the disposal facility. The URLs can also be distinguished by the rock type where they are excavated and whether they are purpose-built or they use pre-existing facilities.

The Generic URLs currently operating are:
- HADES Underground Research Facility (Belgium). Argillaceous rock. Purpose-built
- Josef Underground Research Centre (Czech Republic). Crystalline rock and tuff. Pre-existing
- Olkiluoto Research Tunnel (Finland). Crystalline rock. Pre-existing
- Tournemire Underground Research laboratory. Argillaceous rock. Pre-existing.
- Horonobe Underground Research Center (Japan). Sedimentary rock. Purpose-built.
- Mizunami Underground Research Laboratory (Japan). Crystalline rock. Purpose-built.
. KAERI Underground Research Tunnel. (Republic of Korea). Crystalline rock. Purpose-built.
- Äspö Hard Rock Laboratory (Sweden). Crystalline rock. Purpose-built.
- Grimsel Test Site (Switzerland). Crystalline rock. Purpose-built.
- Mont Terri Rock Laboratory (Switzerland). Argillaceous rock. Purpose-built

whereas the currently operating site-specific URLs are:
- ONKALO (Finland). Crystalline rock. Purpose-built.
- Meuse Haute-Marne Underground Research Laboratory (France). Argillaceous rock. Purpose-built
- Gorleben Exploratory Mine (Germany). Salt. Purpose-built
- KONRAD (Germany). Sedimentary rock. Pre-existing.

A significant number of underground research facilities are no longer operational: AECL URL (Canada), Amelie (France, salt), Fanay-Augères (France, crystalline rock), Asse Mine (Germany, salt), Morsleben (Germany, salt), Pécs (Hungary, argillaceous rock), Tono Mine (Japan, sedimentary rock), Kamaishi Mine (Japan, crystalline rock), Stripa mine (Sweden, crystalline rock), Climax (US, crystalline rock), G-Tunnel (US, tuff), Exploratory Studies Facility Yucca Mountain (US, tuff), WIPP (US, salt). Although operation have been discontinued in these facilities, they have provided over the years very useful information towards nuclear waste disposal. However, there is a danger that some of this information may be irretrievably lost in some instances.



a) **b)**

Fig. 1: Two major URLs a) Generic: Äspö Hard Rock Laboratory (Sweden) in crystalline rock. b) Site specific: Meuse Haute-Marne Underground Research Laboratory (France) in argillaceous rock.

Objectives and role of the Underground Research Laboratories

The objectives of the research carried out in URLs spans the whole range of issues that concerns the construction, operation, closure and safety of a repository facility for high-level nuclear waste. It ranges from basic scientific problems to specific technological developments. Although there are many variants between individual URLs, there is often a common progressive evolution in the type of work undertaken. It starts with the exploration of the basic properties of the rock (baseline state), it is followed by the observation of characteristic processes generated by the interaction of the rock with the waste (including the determination of key parameters) and it concludes with demonstration exercises to prove or otherwise the feasibility of an intended disposal scheme. Other typical activities are the exploration of the excavation effects on the rock and the optimization of construction procedures. In recent years, there has been a tendency towards large-scale long-term experiments under realistic conditions. These experiments may last for more than one or two decades. When they additionally involve a subsequent phase of careful dismantling, extremely valuable information is obtained. Examples of these long-term tests are the Febex test in Grimsel Test Site, dismantled after 18 years of operation (Fig.2), the Prototype Test in the Äspö HRL, the HE-E test in the Mont Terri Rock Laboratory and the PRACLAY test in HADES URF.

Fig. 2: Dismantling of the FEBEX test after 18 tears of operation

In addition to the fulfilment of the purely scientific and technological research objectives, URLs also deliver a number of intangible but very relevant benefits. For instance, URLs provide a natural environment for international cooperation and exchange of concepts and ideas, often going beyond purely contractual agreements. They are also natural training platforms for scientists and technical staff. Properly used, they may become key agents towards the most elusive goal: creating confidence in stakeholders and public at large on the scientific and technical soundness and safety of the proposed disposal schemes.

References

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