Application of matrix-stabilised backfill (GESAV II/SAVER-Project) in HAW repositories in former salt underground mines

L. Schaarschmidt, I. Paschke, D. Freyer, and H. Mischo

TU Bergakademie Freiberg, Germany

INTRODUCTION

Nuclear energy could play a major role in the worldwide clean energy transformation and pave the way to less reliability on fossil fuels. With 437 active nuclear reactors in 30 countries (as of October 2021) there will be a vast demand for final deposition of the used fuel rods and other high active waste[1]. Therefore, a large number of countries are working on final deposition concepts for high radioactive waste.

With the federal law on location decision processes for high active waste (HAW) repositories in 2017, the German government has established official frame conditions for these challenges. Salt rock formations were named as one out of three possible host rock formations for such repositories[2]. This is due to the good heat transportation capacity and the self-healing characteristics of salt; unlike rock types such as granite, salt closes its cracks on it own due to its creeping capability.

In order to store and transport HAW underground, suitable repositories have to be developed. After the waste is stored, the drifts and galleries have to be backfilled again in order to guarantee the restoration of the geological barrier. Due to those boundary conditions, the demand for the applied backfill material is significant. TU Bergakademie Freiberg developed and tested the application of a matrix-stabilised salt backfill material in the GESAV I and GESAV II research projects over the last decade. These two projects as well as the on-going SAVER project are funded by the Project Management Agency Karlsruhe. The agency is one of the biggest sponsors for a variety of repository research projects. The highlight of the developed material is that the backfill body stabilises over a short period of time due to development of polyhalite bridges. Polyhalite is a salt which develops by the addition of kieserite, potassium sulfate, beta-gypsum and magnesium chloride brine to the salt grit. After about ten months the transition to polyhalite is complete and the development of the polyhalite bridges transforms the backfill body from a building comprised of bulk material only to a solid state. Due to the fast development into a solid body, the pressure of the surrounding rock is counteracted in a way earlier state compared to backfill bodies only containing regular salt backfill without any additives. TU Bergakademie Freiberg is currently researching the adaptability of the GESAV backfill method on other material compositions.

[1] World Nuclear Association, 2022. *World Nuclear Association*. [Online]
Available at: http://world-nuclear.org/information-library/facts-and-figures/world-nuclear-power-reactors-and-uranium-requireme.aspx [Accessed 2 February 2022]

[2] German Federal Company for Radioactive Waste Disposal, 2020. *bge.de*. [Online]
Available at: https://www.bge.de/de/endlagersuche/meldungen-und-pressemitteilungen/archiv/meldung/news/2020/7/468-endlagersuche/
[Zugriff am 18th July 2022].

The main goal within the current SAVER project is to further optimise the backfilling method and actually apply it on HAW dummy containers, proving the practical applicability, and thereby providing a highly valuable contribution to various other projects in the field of repository research worldwide. The main part of the project is the execution of big-scale in situ experiments in cooperation with the GSES Sondershausen salt underground mine and the Leipzig Institute of Geotechnics.

In total, two real-life scaled backfill bodies will be stored in place and equipped with extensive measuring and permeability measuring devices. In order to retrieve the data, high-tech data loggers are placed next to the test site which continuously store the data retrieved from the different types of sensor. The sensors are embedded within the backfill bodies. With the emplacement of the dummy containers, the application of the vibrating and slinger backfill method, new knowledge about interactions between different kinds of backfill materials can be retrieved from this project. Moreover, it is planned to investigate how the recovery of these storage dummies can be carried out in the future. Due to the involvement of several institutions with extensive experience in HAW research, valuable input has been received which will lead to the final design of the underground testing sites. Essentially, with this project many questions so far had been left unanswered; these will hopefully be answered in the coming years. Since nuclear energy still plays a significant role in the current age, and might even play a bigger role in the future, research like this marks an important milestone in the energy cycle of modern societies.

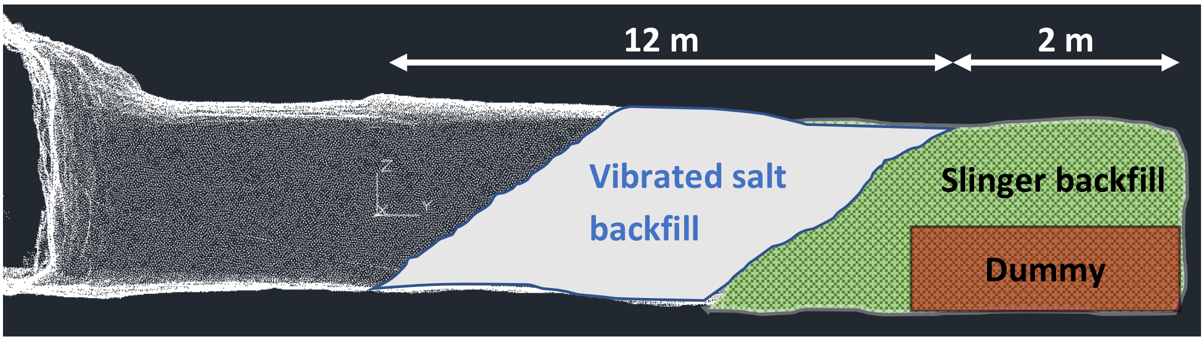

Figure 1. Cross-section of test drift.

The success of this project could certainly provide a big contribution to HAW storage, and also drive after-use of old mines and improve environmental impact worldwide. Due to underground storage, the radioactive waste will not negatively impact flora and fauna on the surface area or put surrounding populations in any danger. Eligible mines can be continued to be used as a storage area instead of simply abandoning them. By this, the reclamation does not only serve an environmental purpose but also provides a safe storage space for HAW. This is obviously on condition that the deposit is generally eligible to be used as a repository. For example, Germany has a very strict determination process for valid mines that fit into that category. Minimum requirements in order for a area to qualify as a potential repository comprise a permeability of less than 10^{-10} m/s, storage area within repository minimal 100 m thickness, minimum depth of repository more than 300 m, sufficient availability of storage area as well as no doubts about barrier effect of the deposit[3].

Due to the application of salt backfill, no additional material has to be acquired in order to fill the storage drifts, which could especially lead to economic benefits. The salt backfill material could be taken from an already existing mine stockpile, then classified, mixed with the salt binder that enables the polyhalite development, and then transferred underground. This would not only guarantee economic feasiblity but also a sufficient supply. Furthermore, using material from the same deposit ensures that there are no unexpected geo-chemical reactions between the backfill material and the rock. The developed concept could be applied in many salt deposits which meet the general criteria for underground repositories and therefore be a huge contribution to worldwide after-use of underground mines or even for newly developed repositories.

[3] (German Federal Company for Radioactive Waste Disposal, 2020)

Louis Schaarschmidt

PhD Candidate
TU Bergakademie Freiberg

I am a motivated and broadly interested professional working with the Underground Mining Department of TU Bergakademie Freiberg researching in the field of radioactive final depositories. After graduating TU Bergakademie Freiberg in 2019 with a Diploma degree in mining engineering, I worked in the quarry industry until Spring 2021. In order to pursue my interest in research and chase my personal ambitions I achieved to get a PhD candidate position at the underground mining department of TU Bergakademie Freiberg, where I am a PhD candidate since June 2021.