Improvement of crushed salt/clay backfill – lessons learned from the shaft seal concept in the Teutschenthal mine

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Abstract:

Crushed salt is the most suitable backfill material for engineered barrier systems in salt environments because of its chemical and mechanical compatibility. In the past most experimental work has been done on compacting pure crushed salt with respect to a use as buffer/backfill material around the casks and canisters in a geologic repository for HLW in rock salt. In addition, a crushed salt column installed in the shaft represents the characteristic long-term sealing element in the level of salt formations due to its compatibility with the surrounding host rock.

However, for confidence reasons a realistic proof of the efficiency and correct operation of the technical sealing concept is essential but large scale experiments are expensive and thus rare. Experiences from conventional shaft sealing projects (e.g. during decomissioning of former used salt mines) may give valuable input for optimization of sealing concepts in nuclear waste repositories. Recently, a shaft sealing concept has been developed for the shaft "Saale" as part of the closure measures of the former potash mine Teutschenthal. Due to the risk of rock bursts backfilling measures with hazardous waste are being performed in the mined carnallite areas requiring a long-lasting and aftercare insolation of the stored harmful substances. Thus their safe long-term containment has to be ensured and demonstrated.

Because the local shaft situation represents an engineering challenge, i.e. the flooded lower shaft part is not accessible, a complex technical closure concept is developed. The shaft plug consists of a self-carrying lower abutment (MgO-concrete) and a series of complementary shaft sealing elements (e.g. Bitumen, Bentonite), separated by MgO-concrete layers. With respect to a redundant and diverse shaft concept also a crushed salt section is foreseen.

To avoid inflow of water to the waste emplacement areas, respectively to exclude an escape of toxic components into the biosphere, the hydro-mechanical integrity of the seal has to be ensured, but again, as a challenge, in the special case of Teutschenthal after only some few decades. Despite it is always stated that crushed salt will finally reach a similar mechanical stability and hydraulic resistance like the surrounding rock salt, an investigation program has been performed to improve the crushed salt compaction using additives like humidity or clay. A preferred crushed salt/clay mixture was selected in close cooperation with the BA Freiberg. With respect to the decisive backfill material properties to quantify hydraulic processes measurements of permeability and porosity were the main objective of the tests.

Our laboratory results confirm earlier results from Stührenberg (2007),that a mixture of 85% crushed salt and 15% swelling clay, respectively bentonite is optimal for backfill measures in shafts:

- The backfill resistance is low $\Rightarrow$ easy dynamic in situ-compaction for shaft sealing;
- Low initial permeability: 10^{-15} - 10^{-16} m^2 (pre-compacted: ca. 15% porosity):
- Compacted wet material (∅ = some few %) has a permeability in the order of 10^{-20} m^2.

Using the new material parameters the hydro-mechanical integrity and the effectiveness of the technical sealing concept has been demonstrated by HM-modeling. Fortunately it came out that already one sealing element is sufficient to ensure the required long-term-tightness.