Large-scale tests to investigate MgO concrete with a long-term stable 3-1-8 phase in the Sondershausen and Teutschenthal mines

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These abstract bases on the R & D project ELSA Phase II - Concept development for shaft seals and testing of sealing elements for HAW repositories, funded by the German Federal Ministry of Energy and Economic Affairs.

The installation of sealing elements in salt rock requires a mechanical support system, which is chemical compatible with the host rock. In future HAW-repositories abutments and sealing elements within the shafts and drifts could be made of magnesia building material with the long term stable 3-1-8 binder phase, if solution containing magnesium can attack the seal.

In 2014 a first large-scale experiment was performed in the Sondershausen salt mine in Germany. A vertical borehole with the depth of two meters and a diameter of 1.1 meter was filled with the magnesia-based concrete. Several sensors measured the development of temperature, comprehensive stress and expansion within the test construction for approximately one year. During the binding reaction the temperature increased by 55 K in the center. After 150 days, the expansion in axial direction reached 2.4 mm/m and 1.1 mm/m in radial direction.

In 2018 a second large-scale-experiment was performed in the Teutschenthal salt mine, Germany to continue the investigations. A new vertical borehole with the depth of 3.5 meters and a diameter of 1.3 meters was filled with the same material. The temperature in the center increased by 40 K during the binding reaction and decreased down to the ambient temperature after 20 days. In result of the first experiences, the stress sensor range was increased. After one year a comprehensive stress of 6.2 MPa was measured at the contour and is still evolving at this point (early 2020). The maximum axial expansion reached 7.9 mm/m and stays at this level. The maximum radial expansion reached 0.7 mm/m 20 days after concreting and decreased subsequently. This material behavior corresponds to the high comprehensive stress level.

The second experiment is equipped with a pressure chamber at the bottom. A first determination of the integral gas permeability revealed a value of approx. $3 \times 10^{-18}$ m² to $3 \times 10^{-17}$ m². In the near term a multistage pressurization of the construction is planned, using a saturated NaCl solution to evaluate the sealing ability.

This contribution reports on the measured parameters (temperature, stress, strain) of the two
large-scale tests with long-term stable MgO-concrete and the composition requirements to obtain a long-term stable MgO concrete. Long-term stable MgO concrete with 3-1-8 phase has been used for the first time in these tests. The measured test-results are the foundation for modelling the behaviour of the MgO-concrete.