Investigations on the permeability of MgO concrete with 5-1-8 phase at the GV2-drift-sealing in the Teutschenthal mine

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For underground storage facilities and future HAW repositories, a secure closure is indispensable. Within the scope of two consecutive research projects, three closure elements were installed in large-scale tests at the Teutschenthal mine in the Carnallitit Mountains between 2006 and 2008. Special mention should be made here of the large-scale test 2 ("GV2"), which was produced from MgO concrete with the 5-1-8 binder phase. This structure was made using the dry-mix shotcrete procedure. The low temperature development during the setting of the shotcrete was very advantageous. The 10.25 m long structure, with a height and width of 3.55 m each, consists of 104 concreting sections with an average layer thickness of 9.9 cm. It was of interest whether the concreting section boundaries ("BAG") influence the permeability (negatively). The structure is equipped with pressure transmitters and TDR sensors in three measuring levels. After completion of the structure and injections in the contact area, the integral system permeability was $2 \times 10^{-16}$ m². Liquid pressurization via pressure chamber was carried out on the test structure after a maturing period of about 10 years. After 8 years, the permeability with gas and with solution was determined in boreholes and on drill cores, especially with regard to the development over time. The determined in-situ gas permeability is on average $2.7 \times 10^{-19}$ m², on compact concrete (without BAGs) on average $2.0 \times 10^{-20}$ m². Test areas containing BAGs showed a higher permeability of maximum three orders of magnitude in some measurements. The solution permeability was determined both with a saturated NaCl solution and with a NaCl-saturated solution containing MgCl₂ and is between $1.0 \times 10^{-20}$ m² and $9.0 \times 10^{-20}$ m², whereby this decreases by half a power of ten over the measurement period of 600 days. In further integral injection tests in 4.5 m and 4.8 m long boreholes, a significant decrease in permeability over time was also observed. From an initial $2 \times 10^{-21}$ m² and $4 \times 10^{-21}$ m², respectively, the integral permeability decreased to $<10^{-21}$ m² over a measuring period of 2.5 years. The reason for this decrease is the reduction of pore space due to the recrystallization of MgO and the transformation of the metastable 5-1-8 phase to the long-term stable 3-1-8 phase due to the increase in volume that takes place when the solution is added. Potential weak points or defects at the technically determined concrete section boundaries, therefore, do not represent weak zones in the structure in the long term due to this self-healing effect.
This paper reports on the large-scale experiment GV2 made of MgO concrete with 5-1-8 phase and the comprehensive permeability and strength investigations in drillings and on drill cores. The test results are the precondition for a modeling of the long-term behaviour of MgO-concrete.