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**Long-Term Safety Assessment and Backfill Strategy
Evaluation for Abandonment of a Brine Production Cavern**

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LONG-TERM SAFETY ASSESSMENT AND BACKFILL STRATEGY EVALUATION FOR ABANDONMENT OF A BRINE PRODUCTION CAVERN

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Abstract

This paper presents the investigation results with regard to the long-term safety and closure strategy for a brine production cavern. The primary objective was to assess the geomechanical behavior of the cavern during the abandonment phase and to recommend a suitable backfill concept for its safe and sustainable closure.

The studied cavern was originally drilled in early 19th century and leached within the rock salt formation, however, extending partially into the overburden composed of salt clay. It was used for brine production for about 90 years and has since remained filled with brine. Based on a recent echometric survey, the cavern has a total volume of about 90,000 m³ (117,716 yd³) and a maximum diameter of 95 m (312 ft). The shape of the cavern can be described as a shallow, inverted cone.

A numerical model based on the Distinct Element Method (DEM) was developed using UDEC software to simulate the operational history and post-closure evolution of the cavern. This model incorporates geological layers from the cavern to the surface, including local topography. A history-matching approach was used to calibrate the model, allowing for the estimation of the in-situ creep behavior of the salt and pre-closure stress conditions.

Assuming a 100-year operational phase during which the cavern remains brine-filled, simulations were conducted to evaluate its long-term structural stability. Upon closure, it was assumed that 95% of the cavern volume would be filled with backfill material, with the remaining 5% forming a residual brine zone. The study considered the potential for brine percolation into the rock salt due to pressure-induced secondary permeability in the rock salt or adjacent salt clay formations. Two closure strategies were analyzed: filling with a single dense backfill material (slurry) and a two-phase system consisting of granulate followed by slurry. Both approaches were evaluated with respect to geomechanical implications, including cavern stability, tightness, and brine percolation potential. The compaction behavior of the backfill materials was incorporated into the model using stress-strain relationships derived from laboratory data. An analytical method was applied to estimate the pressure buildup in the residual brine zone after complete closure.

According to the results, cavern convergence is expected to stabilize within 400 years post-closure. During this time, surface subsidence is predicted to be minimal, suggesting no risk to surface infrastructure or safety. Brine percolation to shallow subsurface layers is not expected, and the integrity of overlying strata is anticipated to remain intact. In conclusion, both backfill scenarios, monolithic dense backfill and two-phase granulate-dense backfill, are considered equally suitable for ensuring the long-term tightness and stability of the cavern. The cavern is expected to remain sealed and structurally stable under both approaches, with negligible environmental impact or surface deformation over the 400-year evaluation period. The results provide a robust foundation for the safe and effective abandonment of a brine production cavern.

Key words: Cavern Abandonment, Long-term Stability, Backfill Materials, DEM Simulation, Percolation