Case study on consequences of cavern convergence on the integrity of cemented production casing strings based on the measurements and numerical calculations.

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Abstract

The efficiency of gas storage in caverns depends on an optimal range between the maximum and minimum gas pressure permitted in the cavern. The maximum storage pressure is reduced to a fraction of the weight of the overburden (typically 0.75 – 0.85 of the vertical stress) to avoid hydraulic fracturing of the salt and/or the cemented well casing. As a consequence of salt creep due to the surrounding stress the minimum gas pressure level is required to ensure the structural stability of the cavern and, in addition, its completion, which must stay intact to provide a safe operation of the gas storage, even in the worst case, leaving the cavern at minimum pressure for longer periods. However, whereas many studies have focused on the salt response during such operation stages, little is known about the impact of salt deformation on the cemented casing string integrity.

To prove the relationship between the cemented casing string behaviour and cavern deformation numerical simulations have been performed. This paper presents a Finite Element Method (FEM) simulation of the cavern convergence based on a constitutive law comprising both, the viscoplastic behaviour of rock salt and steady state creep. Moreover, simulations of strains and stresses in the casing and cement have been done. The input data are from cavern measurements performed by Untergrundspeicher- und Geotechnologie-Systeme GmbH (UGS) and laboratory investigations which have been accomplished by Institut für Gebirgsmechanik GmbH (IfG) Leipzig. These experiments have provided salt and cement parameters.

The simulations have been carried out with elastic and elasto-viscous cement parameters and different cement thicknesses. Furthermore, different cavern shapes and completion designs have been investigated to find out their influences.

Various case studies show the practical conformance of the simulation results such as the excellent accordance of the completions movements determined by the calculations and by the measuring system installed on the caverns heads. The simulations of the casing and cement strains and stresses allow setting the time limits for the standstill with the minimum pressure. A longer time can lead to the failure in cement.