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More flexibility for the gas storage caverns in Staßfurt:

Re-analysis and prognosis of the load-bearing behavior by numerical simulations

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Abstract

Numerical simulations were performed in order to get information about the load bearing behaviour of the natural gas storage cavern S107 in Staßfurt. The shape of cavern S107 is characterized by a distinct waist and an extraordinary long neck. Based on a finite difference model (FDM) of this cavern, the stress history since the start of its gas storage operations in 1998 was re-analysed first. In the second step different prognostic operation modes were investigated including all three phases of salt creep (primary, secondary and tertiary i.e. damage-induced creep). The material model Lux/Wolters was chosen for the characterization of this behaviour as it considers damage-induced (tertiary) creep of rock salt.
For the re-analysis rock mechanical lab test data from caverns nearby (S106, S108, S110 and S111) were used to conclude the creep parameters of the Staßfurt rock salt for the material model Lux/Wolters. Also p_i and T_i (vs. time) as well as the amount of convergence could be inferred from existing data.
In total four different prognostic scenarios, each with 5 year duration (2015-2020), have been investigated by numerical simulations in order to offer more flexibility to the storage customers. Based on seasonal turnover operations, threefold annual turnovers were added one to five times over the five years. With this procedure only negligible cavern damage was caused. Therefore another scenario with sixfold annual turnovers over five years was added.
Then the load bearing behaviour of the cavern S107 was studied. Basically the re-analysis revealed cavern stability and tightness over the load history (1998-2015). Firstly only short term and insignificant exceeding of the dilatancy strength occurred. Secondly only few cavern zones bore the risk of gas infiltration into the cavern contour due to the special shape of cavern S107. The prognostic scenarios with several annual turnovers and different loads showed comparable results. Especially the dilatancy strength was exceeded for longer time intervals than in the historical analyses. The abovementioned tightness criterion again was only critical in few zones of the cavern contour. Nevertheless tightness of the surrounding salt rock mass was proven.
Summing up the options for more flexible future operations of the gas storage caverns in Staßfurt were demonstrated by example of the cavern S107. If more flexible operations with more than one annual turnover will be requested for the new caverns S113-S116, then the lab tests for these caverns will be performed including a re-assessment of the dilatancy strength that was only estimated conservatively in this study. Moreover the healing behaviour of the Staßfurt rock salt, that has been disregarded here, would then be considered to improve the results of the stability and tightness assessment for all requested scenarios.

Key words: Gas storage, Zechstein, salt caverns, rock mechanics, numerical simulations, flexibility