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Issues concerning the abandonment of deep brine-filled caverns

Discussion paper (revised)

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Abstract

The reason for this discussion paper are some generalizing rock mechanics notions regarding brine-filled cavern abandonment that are presented during SMRI conferences. Two notions are to be mentioned: 1) when brine pressure is larger than geostatic pressure hydro fracking of salt is likely, and 2) thermal equilibrium *must* be reached in a brine-filled cavern before its (final) abandonment. Consequently, large caverns require very long periods for reaching equilibrium, e.g. one century.

The meant notions need further discussion and, moreover, evidence-based revisions. Evidence is collected in this paper and primarily consists of practical observations and the development of new rock mechanical modeling concerning sealed deep caverns in Germany and the Netherlands. Also, the pressure observations that apparently evoked the notion on salt hydro fracking are reinterpreted.

The representative cavern-sealing studies, dealt with in this report, comprise pressure observations, numerical model simulations, theoretical backgrounds and several recommendations concerning the definite closure of deep brine-filled caverns. Based on this information a synthesis of data and conclusions has been performed.

No indications have been found for the occurrence of hydraulic fracturing of salt, when brine pressure tends to exceed lithostatic pressure. According to this author, the typical observations, heretofore interpreted as occurrence of hydraulic fracturing, can be explained and understood by other, more plausible mechanisms causing the observed wellhead pressure trends.

Furthermore, thermal equilibrium between cavern brine and surrounding salt body seems not a critical prerequisite for safe cavern sealing. The only essential consequence of significant lack of thermal equilibrium at final cavern closure is an acceleration of brine infiltration in the salt formation above and besides the cavern roof and an earlier escape of brine into a porous and more permeable cover rock.

Anyhow, the brine infiltration process cannot be prevented, but at best delayed by beforehand requiring thermal equilibrium. The real long-term driving force behind brine permeation is the density difference between the brine column in the cavern and the ambient salt formation and overburden rock.

Notably, in deep Frisia caverns strong indications have been found that, at the moment of final brine extraction stop and hard cavern shut-in, a significant ‘pressure sink’ was prevailing in the salt envelope around the cavern. This explains why, contradictory to numerical model simulations, the brine pressure increased very slowly despite an initial temperature gap of 29 K and did not by far reach lithostatic values, not even after more than 10 years of cavern shut-in.

Finally, the author concludes from this synthesis that requiring brine thermal equilibrium before sealing-off brine-filled caverns is unpractical. A waiting period is not automatically necessary in view of safe cavern abandonment and economic business perspective.

Aspects of cavern abandonment more essential in view of long-term safety and environmental protection are, for example, the determination of where in the subsurface storage capacity is available for brine flowing out of the salt formation, the eventual risk of shallow-groundwater salinization and the amount of short-term and final land subsidence to be expected.