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Temperature induced and gas-pressure driven fractures in rock salt: Insights from numerical calculations and laboratory measurements

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As part of a stable supply of energy, the importance of storing natural gas, compressed air and hydrogen in gas storage caverns in rock salt has increased over the last decades. Especially, the storage of compressed air and hydrogen has gained wide attention during the last years in order to increase the storage capacity of renewable energies. In any case, the safety and gas-tightness of gas storage caverns are essential and of great importance.

Gas temperature within operated gas storage caverns decreases during withdrawal phase. This can lead to the development of tensile stresses at the cavern wall. It is likely that tensile stresses lead to fracturing because the tensile strength of rock salt is relatively low compared to other rocks. If fractures are created, the gas penetrates into the cracks leading to a further propagation under certain circumstances.

The current state of technique does not allow the observation of fracturing at the cavern walls. Therefore, numerical simulations and laboratory experiments as presented here are essential for a better understanding of these processes. It is currently subject of research to investigate the process of thermally-induced and gas-pressure driven fracturing as part of safety assessment of gas storage caverns. It has to be investigated how far cracks penetrate into the surrounding rock salt in case of fracture initiation. In addition, it has to be examined if crack propagation continues due to cyclic gas pressure changes or if it stops at a certain penetration depth.

The theoretical approaches of thermally-induced and gas-pressure driven fracture propagation in rock salt are presented here. To investigate the process of temperature-induced and gas-pressure driven fractures in rock salt, time-dependent, thermo-mechanical coupled numerical calculations were performed. The results show that fracturing is initiated by a local decrease in temperature and fractures propagate due to the gas pressure depending on its strength and the overall stress state. Finally, a newly developed laboratory device is presented to additionally investigate fracturing processes in the laboratory. Results obtained from the numerical calculations and laboratory experiments are helpful for a more accurate understanding of large and small scale thermo-mechanical fracturing processes in the surrounding rock salt mass of gas storage caverns.