Is it moving? – the occurrence and migration of gas in salt rocks

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In the course of a sustainable energy usage, the demand for temporary gas storage space is highly increasing. Technical caverns in salt formations, created by salt solution mining, hold great potential for the storage of various gases. To ensure their integrity and safety, a detailed understanding of the multiphase system salt–gas–water in the transition zone between cavity and solid rock is required.

Due to the inaccessibility of conventional storage caverns, analog structures in an underground salt mine were used to measure gas concentrations in evacuated and packer-sealed boreholes located in different salt lithologies.

Furthermore, an artificial 300 l test cavern in a subsurface salt pillar was used for in situ experimental simulations. Experiments under dry and wet conditions and various gas loads, such as SF_6 labeled CO_2 and gas mixtures (H_2, CH_4 etc.) with up to 1.5 MPa, were performed.

Results show, that intact rock salt formations are technically gas tight. However, a temporary increase in gas concentration was observed in a discrete area along a newly formed fracture formation. The event was short-lived which indicates a fast remineralization of fracture openings. A general spatial correlation of gas content in the rock salt formation with distance to a natural CO_2 bearing cavernous structure could not be observed.

In contrast, fast gas migration could be observed in inhomogeneous salt rock structures, containing magnesium- and potassium-rich salt minerals as well as clay lenses. During monthly sampling campaigns, the migration of various gas species, such as Ar, CO_2, SF_6, H_2, CH_4, was observed at different distances from the cavern. During the migration of the injected gas, salt-bonded gases (CO_2, CH_4, H_2, He) were stripped from the salt rocks and enriched in the migrating injection gas. This indicates, that the fossil salt gases were trapped along migration pathways which are primarily grain boundaries and microfractures. This agrees with fluid inclusion observations, where CO_2 and CH_4 is lacking in fluid inclusions within salt minerals. The isotopic characterization of CO_2 and He points to a mantle source, whereas CH_4 may be generated thermogenically. This implies an allochthonous origin with a subsequent fluid influx from surrounding rocks.