Geophysical Research Abstracts
Vol. 21, EGU2019-3075-1, 2019
EGU General Assembly 2019

Geochemical investigation of fluid-rock interactions in the transition zone of lab-scale salt caverns

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Salt caverns result from solution mining of bedded or domal saline structures. Such caverns are gaining in importance as a temporary geological storage for fluctuating renewables with view to securing a stable energy supply.

Generally, salt rocks are regarded as highly impermeable and their geomechanical and hydraulic properties are well constrained. However, to assure the integrity of caverns during operation and long term abandonment, knowledge of geochemical rock-water interactions in the transition zone between cavity and salt rock is necessary. Of special interest are intercalations of potassium-rich salt beds that show different characteristics in terms of dissolution-recrystallization reactions.

Due to the inaccessibility of cavern walls, a set of lab-based experimental simulations were performed mimicking cavern leaching. In large hand specimen cm-sized cavities were created by coupling fresh water injection and brine removal. Afterwards, the samples were cut to expose the cavity and its surrounding rim. For the identification of mineral composition around the cavity two techniques were used.

Micro X-ray Fluorescence mapping was employed to obtain information on element distribution to conclude on mineral compositions. Analyses were performed every 50 [U+F06D]m on the rock surface around the cavern. The mapping results provide details on the distribution of the elements Na, Mg, Al, Si, S, Cl, K, Ca, Fe, Br, Sr and can be associated with the main salt-minerals assemblages. The XRF mapping results reveal a clear separation between Na, Mg and K salt layers.

Furthermore, hyperspectral image analyses were used to characterize the spatial distribution of minerals due to their spectral footprints. Image spectroscopy covers the optical and short-wave infrared regions across the 400-2500 nm spectral range.

First results are presented here, showing that these methods are promising in detecting mineral dissolution and precipitation reaction in salt and are, thus, useful tools in unravelling geochemical processes related to marginal areas of cavernous structures in salt deposits.