Geophysical Research Abstracts
Vol. 21, EGU2019-7889, 2019
EGU General Assembly 2019

Potash salt composition governs the formation of geogenic caverns

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In Germany, salt deposits play an important role as industrial raw material as well as sites for energy storage. However, in geological fault zones, dissolution of the salt body due to contact with migrating groundwater may ultimately lead to the formation of geogenic caverns and subsidence of overlying structures representing a high risk to active potash mining. Due to the high solubility of potash salts, cavern growth is facilitated in potash seams compared to solid rock salt.

Using the software PHREEQC (Parkhurst & Appelo, 2013) the dissolution behavior of potash salt has been investigated systematically and the results were compared to field measurements. A titration model for varying compositions of hard salt has shown that several components within the potash seam, i.e. halite, are only partly dissolved, while others, i.e. carnallite, are fully converted into secondary minerals. During that conversion process, brine composition and precipitations mainly depend on the ratio between kieserite and sylvite. Several field measurements from a salt mine showed consistency with calculated brine compositions, especially for kieserite-rich potash salts. The dissolution process only stops if water, kieserite or sylvite is fully depleted. As a consequence, 1 kg of brine can influence several tens of kilograms of potash salt.

In a further step, a 1D model was generated in order to characterise brine composition across the transition zone between a cavernous structure and unaffected rock. Results show that the brine composition along the transition zone matches the reaction pathway of the titration model. The zone can be divided into different mineralogical regions, containing secondary minerals like glaserite, leonite or kainite besides halite. These calculated minerals were also found around naturally occurring fault zones. Volume analyses also show that cavern growth requires an open system with a minimum exchange rate. Furthermore, new void spaces are only formed at the beginning of the transition zone (close to the center of the cavern). Transferring the modeling results to a mine is supposed to facilitate an early detection as well as a safe long-term retention of caverns within salt rock.

References:
Parkhurst, D. L., Appelo, C. A. J. (2013): Description of input and examples for PHREEQC version 3 - a computer program for speciation, batch-reaction, one-dimensional transport, and inverse geochemical calculations. US Geological Survey Techniques and Methods, 6 (A43), 497 p.