Geogenic Caverns in Rock Salt Formations – A Key to Genetic Processes and Hazard Potential

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Extended Abstract

Geogenic caverns are typical geological phenomena in large-scale rock salt formations which occur with a spatial dimensions of a few decimeter to several decameter. They are filled with natural brine, gas or recrystallized salt minerals. Generally, evaporitic rocks, especially rock salt, sylvinite and other potash salts are prone to dissolution or diagenic alteration. Major processes which are linked to the origin of intrasaliniferous caverns include the recrystallization of salt minerals, the dissolution of evaporites by intruding groundwater, or volcanic intrusions from the Earth's mantle. Those processes may form large intrasaliniferous caverns, which may collapse and potentially affect the landscape above and underground mining operations.

Despite their common appearance, geogenic intrasaliniferous caverns remain a significant issue in underground salt and potash mining safety. Many studies have focussed on the occurrence, geochemistry and hydrology of intrasaliniferous brines (Herbert and Schwandt, 2007). However, the origin of geogenic caverns has not been studied yet in detail.

In this study we present an overview of the known types of intrasaliniferous caverns. We establish a classification with respect to the existing tectonic regime, the brine type, as well as the hazard potential for underground mining and above ground. We focus on own field data from the Upper Permian Zechstein formation, data and reports from former and present-day potash and rock salt mines as well as interdisciplinary studies with respect to dissolution processes, brine hydrology and tectonic conditions in evaporites.

The observed examples indicate two general types of intrasaliniferous caverns. On the one hand, atectonically formed caverns are related to post-depositional intrasaliniferous processes regarding the metamorphism of carnallite rock to sylvinite (Pippig, 1992). This process is linked to a significant reduction of rock volume, which creates small-scale caverns. On the other hand, tectonically-formed intrasaliniferous caverns demonstrate a more complex origin, which is strongly linked to present or fossil solution paths (open or closed hydrological system), the saturation and dissolution potential of the intruding brine and the number of the existing tectonic lineaments.

A risk analysis of the studied caverns and dissolution scenarios indicates that atectonic intrasaliniferous caverns show a very low hazard potential, because of the limited space and brine volume in a closed hydrological system. The brine is mostly saturated in potash and salt minerals and has no or a very low potential for dissolution of the in-situ salt rocks and pillars. In contrast to atectonic caverns, tectonically-formed intrasaliniferous caverns show a higher hazard potential. They are formed at fossil or present solution paths and demonstrate open hydrological systems with a hydraulic connection to aquifers under and above the evaporite formation. The hazard potential increases with lower saturation of the involved brines or saline formations waters and the existence of multiple tectonic elements.

Despite the general geogenic hazard potential of caverns in rock salt formations, the hazard potential in underground mining is uncritical, due to close meshed exploration. Safety-related exploration in rock salt and potash mines include horizontal drilling, drill hole radar and seismic surveys in order to identify potential brine migration paths (basement faults, protective layer faults), areas of brine penetration and brine-related alteration of potash and rock salt beds.

Key words: Geogenic brine, rock salt, mining, caverns

References

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