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Forensics in a salt mine: using isotopes to reveal the origin of CO_2 and its interactions with saline water

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Technical caverns in salt deposits formed by salt dissolution are important for energy storage. However, naturally occurring cavernous structures also pose a challenge for underground mining, especially, if they contain larger amounts of fluid or pressurized gas. Thus, further knowledge about caverns and cavernous structures is crucial for salt mining and their potential technical use. Due to the poor accessibility of caverns little is understood about their geochemistry. Here we introduce how CO_2 isotopes may serve as a tool for defining the origin of the gas and its interactions with fluids in salt deposits. This may help to improve the detection of such permeable zones connected to cavernous structures.

We investigated a cavernous structure in a salt mine that is filled with both, saline water and gas. The latter is dominated by CO_2 with volumetric contents of more than 90 %. Preliminary results on CO_2 isotope analyses were obtained by laser mass spectroscopy. Stable carbon isotope compositions of CO_2 from and near the cavernous structure had $\delta^{13}C_{CO2}$ values between -6.1 and -2.9 ‰). These are typical values for CO_2 from the mantle and may originate from the Tertiary Rhön and Vogelsberg volcanism. Within the mine, we also found $\delta^{13}C_{CO2}$ values that are typical for those of fresh air (-12.7 to -11.1 ‰) and anthropogenic influences (-31.3 to -29.8 ‰). Hence, these values can help to differentiate geogenic origins of CO_2 from other sources.

In future work, we aim to investigate oxygen isotope compositions of CO_2 and H_2O in saline waters of the mine in order to explore water–CO_2 interactions. Further investigations are directed at isotope compositions of water in mineral structures in order to outline potentially variable sources of water during and after salt deposition. These investigations will be performed by laboratory tests under controlled conditions. Furthermore, experiments using an artificially formed cavern in the mine are planned. These will open new opportunities to track CO_2 migration behavior under controlled conditions in an underground salt deposit.