Detection of mantle CO2 in an underground salt mine via long-term and high-resolution monitoring by laser-based isotope techniques

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Salt deposits may be affected by post-depositional CO\textsubscript{2} intrusions. In central Germany, such CO\textsubscript{2} contributions from the mantle may originate from Tertiary Rhön- and Vogelsberg-volcanism. The intrusion of those gases may cause technical and operational implications for storage caverns and salt mines.

Carbon isotope compositions of CO\textsubscript{2} are useful tools to differentiate between sources and are expressed as $\delta^{13}$C values in ‰ versus an international standard known as the Vienna Pee Dee Belemnite (VPDB). Typical average endmember values for CO\textsubscript{2} from the mantle are -5.1 ‰, while background air and anthropogenic influences range around averages of -11.9 ‰ and -29.8‰. Detection of fluctuations between these endmembers can be challenging with discrete sampling. This can be overcome by high-temporal resolution and long-term monitoring.

Towards this purpose, a laser-based isotope system was set up in an active underground salt mine in central Germany. For 34 days, continuous measurements of $\delta^{13}$C and concentrations of CO\textsubscript{2} were generated close to a site where mantle CO\textsubscript{2} intrusions were suspected. A timer regularly switched intakes from two capillaries, of which one was placed inside a borehole and the other in ambient air of the mine. Measured CO\textsubscript{2} concentrations ranged between 700 and 1600 ppmV, while $\delta^{13}$C values ranged between -21.5 ‰ and -11.5 ‰. Lower concentrations coincided with more positive isotope values and occurred around weekends when anthropogenic influences in the mine were less.

While influences of fresh air venting may have caused these weekly shifts, the admixture of mantle CO\textsubscript{2} seemed to play a continuous role. This is because small differences between the capillary from the borehole and the one with ambient air existed throughout the time series. Our results indicate that short-term dynamics on the order of hours to days are overlain by admixtures mantle gas intrusions of CO\textsubscript{2}.