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Comparison of shallow aquifer and soil gas monitoring approaches for detecting CO_2 leakage at a natural analogue site in France

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Natural analogue sites where geologic CO_2 is leaking to the surface provide excellent opportunities to test approaches suitable for monitoring for potential CO_2 leakage at carbon capture and storage sites. We tested isotope monitoring approaches for CO_2 detection in shallow aquifers and the overlying soil zone at a CO_2 analogue site near Sainte-Marguerite in the Massif Central (France). The Sainte-Marguerite area is located in the southern part ofthe Limagnegraben(FrenchMassif Central).Thebasement, composed of highlyfractured granite, outcrops toward the west of the study area,notably around the Saladis spring. An intercalated arkosicpermeable interval between fractured granite and Oligocene marls and limestonesacts as a stratiform drain for fluid migration while the overlying thick Oligocene interval is impermeable and acts as aseal. The Allierriver bed is located near the contact betweenthe basement and the sedimentary rocks. Deep CO_2-ladden fluids migrate through the arkose intervaltoward the Sainte-Marguerite area and sustain a number of local springs.The Sainte-Marguerite area is known for the travertinedeposits associated with the CO_2-rich natural springs.

We collected water samples and effervescentgases at the springs as well as soil gases for chemical and isotopic analyses. The analytical parameters included major anions and cations, $\delta^{13}C$&$\delta^{18}O$ of CO_2, δD&$\delta^{18}O$ of H_2O and $\delta^{13}C$ of dissolved inorganic carbon (DIC). Preliminary results revealed that $\delta^{13}C$ values of CO_2 in most groundwater and soil samples were similar. Oxygen isotope measurements revealed equilibrium between CO_2 and H_2O-oxygen in most samples, but except for a limited number of samples,$\delta^{18}O$ values of water did not deviate significantly from the local meteoric water line. Our preliminary results suggest that both the groundwater and the soil sampling approaches should be capable of detecting leakage of CO_2 provided that the leaking gas has a distinct isotopic composition. The thresholds of leakage detection are currently determined in laboratory column experiments, where CO_2 of known isotopic composition is bubbled through a water-saturated sand at different rates and continuously measured for its $\delta^{13}C$ and $\delta^{18}O$isotope composition using laser spectroscopy. The potential for isotope exchange between oxygen from water and oxygen from bubbling CO_2 is also evaluated.