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# The $CO_2$ Vadose Project - Buffering capacity of a carbonate vadose zone on induced $CO_2$ leakage. Part 1: monitoring in a natural pilot experimental field

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The Intergovernmental Panel on Climate Change Special Report on Carbon Capture and Storage identified various knowledge gaps that need to be resolved before the large-scale implementation of $CO_2$ geological storage to become possible. One of them is to determine what would be the impact of a $CO_2$ leakage from a geological storage on vadose zone and near surface environment.

The $CO_2$-Vadose project aims at i) understanding the behavior of $CO_2$ in the near surface carbonate environment during an induced $CO_2$ leakage, ii) assessing numerical simulations associated with $CO_2$ release experiments and iii) developing integrated field methodologies to detect and quantify a potential $CO_2$ leakage. A gas mixture of $CO_2$ and tracers (He and Kr) was released in a cavity (9 $m^3$, 7 m deep) located in an abandoned limestone quarry in Gironde (France). More than forty gas probes were set up (in the near surface and all around the cavity in limestone) for following $CO_2$ concentrations before, during and after injection thanks to micro-GC and Li-Cor analyzers. The meteorological parameters were recorded at the site surface as well as around the injection room. Experimental observations of variations of electrical resistivity were also carried out in order to investigate the evolution of limestone geophysical property in response to possible leakages of geologically sequestered $CO_2$. The dynamic evolution of electrical resistivity was measured thanks to time-lapse electrical resistivity tomography.

Natural ground and limestone $CO_2$ concentrations were monitored during a year before $CO_2$ injection. Natural $CO_2$ concentrations variations were observed in order to plot a natural baseline and so to determine the best period for the injection and to distinguish biogenic from injected $CO_2$. These concentrations varied between about 400 ppm to more than 20,000 ppm, following cycles of about six weeks. Initial electrical resistivity tomography was also carried out just before the injection in order to have reference values and to characterize the heterogeneity of the limestone massif around the injection room.

The diffusion of $CO_2$ was followed thanks to $CO_2$ gas concentration measurements and resistive tomography. The numerical simulations done with COORES$^{TM}$ code were in good agreement with experimental results near the source. The results of this study show that $CO_2$ subsurface leakage can be anticipated thanks to inert gases used as tracers, like He and Kr. As part of a monitoring plan, the detection of noble gas increase could lead to the surveillance of the monitored area with accuracy, permitting to discriminate leakage $CO_2$ from natural one.