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1 Isotopic and geochemical characteristics to monitor fluid-rock interactions, following a small scale CO_2 injection

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Carbon dioxide geological storage in deep aquifers is one of the most promising alternatives to reduce CO_2 emissions to the atmosphere. In this context, CO_2 geological storage, via geochemical trapping, would be achieved according to three mechanisms sequentially ordered: solubility, ionic and mineral trapping. The mineral trapping is the most permanent and thus secure form of geochemical trapping but it is the slowest mechanism since the in-situ dissolution rates of e.g. Ca, Mg silicate minerals are slow (Gunter et al., 2004). Studies related on CO_2-fluid-rock interactions showed that the chemistry of formation water and rock mineralogy of the reservoir play a determinant role on the efficiency of the CO_2storage. Gunter et al. 2000

In order to investigate the extent of in-situ CO_2-fluid-rock reactions relevant to the effectiveness of CO_2sequestration, 3 single well push-pull tests (1 blank test “non reactive test” and 2 CO_2 tests “reactive test”) were performed in a basaltic rock aquifer at the Lamont-Doherty Earth Observatory test well site, New York. It includes an instrumental borehole of a total depth of 304 m, which cuts through most of the section of the Palisades sill and into the Newark Basin sediments.

Using a straddle packer system, a test solution was injected (“pushed”) in a hydraulically isolated and permeable zone, at a depth interval located between the Palisades sill (chilled dolerite) and the underlying Newark Basin sediments (metamorphosed sediments). Conservative chemical and/or isotopic tracers (NaCl, D, ^{18}O) were added to the test solution. For the CO_2 tests, the test solution was additionally equilibrated with a $CO_{2(g)}$partial pressure (1 and 8 bars). After an incubation period (ranged between 1 and 3 weeks), the test solution/background water mixture was continuously pumped back ("pulled") from the hydraulically isolated zone. Physico-chemical parameters were measured ex-situ (pH, temperature, electrical conductivity) and sealed samples were collected for isotopic ($\delta^{13}C_{DIC}$, $\delta^{18}O$, δD) and chemical (DIC, major ions) analyses.

For the blank test, the injection of a CO_2non-saturated fluid reveals only a mixing process between the background water and the injected water and, the invariance of the fluid compositions confirms the non-reactivity of this test. For the CO_2 tests, the variations of the chemical and isotopic fluid compositions are due to two main processes: (1) mixing between the background water and the injected water and (2) CO_2 reactivity (reactions of the dissolved CO_2 with the surroundings rocks and CO_2 degassing (for the fluid equilibrated with the higher partial pressure)). The main consequence of the CO_2 reactivity was the dissolution of carbonate minerals (fracture fillings) and to a lesser extent the dissolution of primary minerals such as Ca, Mg silicates from the basalt. The release of alkaline earth metals by the acid neutralization reaction sets the stage for the subsequent formation of new, secondary carbonate minerals, and therefore for the mineral trapping of CO_2 (Matter et al., 2006).