Geophysical Research Abstracts
Vol. 17, EGU2015-9671, 2015
EGU General Assembly 2015

Time-lapse downhole electrical resistivity monitoring of subsurface CO_2 storage at the Maguelone shallow experimental site (Languedoc, France)

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A shallow field experimental site for CO_2 injection was established at Maguelone (Languedoc,France), in order to test in an integrated manner a suite of surface and downhole hydrogeophysical monitoring methods. The objective is to improve our understanding of gas transport in the shallow subsurface and to determine the sensitivity of CO_2 monitoring systems for leakage detection. The site offers a natural laboratory to study the processes associated with CO_2 injection in a clastic and clay-rich context saturated with saline fluids. Prior to CO_2injection, three nitrogen (N2) injections were undertaken in 2012 to measure the site response to neutral gas injection. In 2013, a volume of 111 m3 of CO_2 was injected during 3.5 hours at 15 meter depth. During each experiment, the gas plumes were successfully detected from pressure monitoring, time-lapse induction logging and downhole resistivity monitoring with downhole dipole-dipole arrays. Increases in resistivity are attributed to free gas propagation (either N2 or CO_2) whereas decreases in resistivity correlate with CO_2 dissolution in the pore fluid. Chemical analyses confirm this hypothesis with a decrease in pH and an increase in the concentration of dissolved species in the later case. The next stage of the project will be performing the CO_2 injection experiments with improved monitoring schema using results of the present study. In perspective, besides of improving our understanding of gas transport in the shallow subsurface, the additional issues could not just show a capability of used geophysical and geochemical techniques to monitor the CO_2 plume and to detect near-surface CO_2 migration pathways, but to help quantifying potential CO_2 migration.