Geophysical Research Abstracts
Vol. 14, EGU2012-10027, 2012
EGU General Assembly 2012

SIMEx : a shallow integrated, multi-method hydrogeophysical monitoring experiment for CO_2 storage conducted at Maguelone (Languedoc coastline, France).

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The objective of the SIMEx experiment (Shallow Injection Monitoring Experiment) is to test at decameter scale and in an integrated manner a full suite of coordinated hydrogeophysical monitoring techniques, either from surface or downhole. The experimental site for SIMEx was set-up at Maguelone near Montpellier (France) in the context of MUSTANG EC project (FP7). Limited to the north by a coastal lagoon and to the south by the Mediterranean sea, this site offers a natural laboratory to study saline coastal reservoirs in a clastic and clay-rich context. The field spread includes an injection hole, a time-lapse logging hole, downhole electrical observatories at variable distance from the injection point, a downhole hydrodynamic observatory based on a multipacker completion from WestBay (SWS), a downhole seismic observatory, plus surface electrical and seismic observatories. In particular, the downhole technology developed by "Geosciences Montpellier" and "imaGeau" is to be adapted to resist the aggressive conditions encountered for CO_2 underground storage, and pressure conditions down to 2000 m depth. This coordinated set of observatories is meant to lead to the design of integrated downhole sensors and methods for the monitoring of gas injection in deep reservoirs.

Continuous geological samples and geophysical data from shallow boreholes have lead to identify two depositional sequences: from surface to 9 m depth, Late-Holocene lagoonal sediments (mostly impermeable dark green clays) forming an impermeable seal overlying homogeneous fine-grained Pliocene continental deposits (clays, silts, and carbonates). In this sequence, fluvial conglomerates and sandstones are drilled from 14 to 17 m. Sedimentary facies, geophysical measurements and hydrological testing indicate a high permeability and porosity for these conglomerates, also bounded above and below by clay-rich horizons. Hydrogen sulphite (H2S) encountered in a repetitive fashion during coring and drilling operations near 15 m depth confirms the presence of a small reservoir at this depth.

Prior to gas injection, a whole set of pre-injection experiments have been conducted in order to prepare, test, and calibrate the Maguelone site for later experiments. The initial physical properties of the reservoir layer have been successfully characterized using downhole geophysical measurements (gamma ray, electrical and acoustical logging), followed by surface (electrical and seismic tomography) and surface-to-borehole (seismic) surveys.

More recently, nitrogen injection was undertaken to measure the site response to gas injection. Nitrogen was chosen because of the reducing nature of the in-situ environment present in the shallow subsurface at Maguelone, precluding oxygen injection to avoid massive bacterial developments. The next phase of SIMEx will be that of CO_2 injection using similar surface and downhole hydrogeophysical monitoring.