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The LEMAM array for CO2 injection monitoring: modelling results and baseline at Ketzin in August 2008

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Several teams have proposed to follow the variation of electrical resistivity at depth in order to monitor the CO_2 injection. This approach seems especially relevant in the case of CO_2 injection in saline reservoir where the CO_2 plume is expected to generate a strong increase of the electrical resistivity.

Due to its greater density, supercritical CO_2 occupies a much smaller volume and shows reduced buoyancy as compared to gaseous CO_2. The reservoir should thus be deep enough for the CO_2 to be in a supercritical state. Assuming a geothermal gradient of 25˚C/km from 15˚C at the surface, and a standard hydrostatic pressure, CO_2 is supercritical at depth greater than 800m. And many envisaged reservoirs are even much deeper. This makes it very difficult to detect and monitor any change in the reservoir using electrical methods from the surface. Logging and cross-well electrical or electromagnetic (EM) imaging overcome this limitation but they need wells intersecting the reservoir and compatible for such measurements. In addition, the lateral investigation is limited to the inter-well area or to the close vicinity of the unique well in the case of logging or single-well methods.

We propose to illuminate the deep CO_2 plume by a grounded injection of electrical current through the available metal-cased boreholes (CO_2 injection or monitoring boreholes, possibly pre-existing boreholes in the case of depleted hydrocarbon reservoir) which act as long electrodes and to measure the resulting electric field at the surface. We designate this array as Long Electrode Mise À La Masse (LEMAM). Considering industrial-scale CO_2 injection rates ($\approx$ 1 Mt/y), the first numerical simulations performed within the projects GeoCarbone-Monitoring and EMSAP-CO_2 of the French Research Agency (ANR) have shown that, even for a reservoir as deep as 2000 m, when the volume of the plume increases, the resulting electric field modification at the surface is perfectly measurable. Furthermore, this array shows a good sensitivity to the plume shape.

In the framework of the CO_2ReMove EC project, a baseline with the LEMAM array has been performed at the Ketzin site in August 2008, at the beginning of the CO_2 injection. Repetitions are planned in 2009 and later as a first field application of the LEMAM array to CO_2 storage monitoring. The surface electric field was recorded using several pairs of perpendicular electrical dipoles (100 m length) distributed in the area surrounding the CO_2 injection borehole (approximately 1 km around the borehole head). It will be interesting to compare our results with the electrical resistivity monitoring performed in the framework of the CO_2SINK project, using either cross-borehole electrical resistivity tomography (VERA experiment, Helmholtz Centre Potsdam/ GFZ) or surface injection coupled with surface-downhole-measurements (in cooperation with University of Leipzig).