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Laboratory-scale measurements of self-potentials during CO_2 releasing.

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Carbon sequestration projects include monitoring programmes focused on tracking evolution of injected gas. Induced changes in porous media triggered by degassing in case of leakage comprise chemical reactions and fluid motion. These processes are likely to induce Spontaneous Potential (SP) signals that can be detected on surface with proper arrange of electrodes (Girard & Bitri, BRGM report 56299, 2008; Byrdina et al., JGR 114, 2009). Here we attempted to reproduce such leakage scenarios at the laboratory scale.

Different arrays of unpolarisable electrodes were placed in a rectangular, plexiglas box containing Fontainebleau sand saturated with 0.56 NaCl g/L water solution. Measurements were systematically recorded during stages of i) initial conditions (i.e., without gas flow), ii) low rate CO_2 injection, iii) increased CO_2 injection rate and iv) post injection. CO_2 injection was performed in one half of the tank by means of a cylindrical air diffuser. That device allowed us to homogeneously distribute gas for better comparing differences between signals in the perturbed zone and the non-perturbed zone. The whole set-up was designed to be an open system since gas reaching the surface of the tank affects no longer the signals. Acquisition was made with a High impedance voltmeter Keithley 2701. Because we wanted to analyse possible effects of the investigated volume and signals, we registered under similar conditions SP responses with three different unpolarisable electrodes ($Cu/CuSO_4$, Ag/AgCl and $Pb/PbCl_2$) having different measuring area.

Signals obtained display a congruent behaviour. However, under identical procedure conditions we didn't observed similar values in terms of amplitude. The general trend suggests that the responses are subordinated to the amount of gas reaching the zone on the interface electrode/media. The perturbed zone is characterised by higher voltages, especially in areas with more degassing. Beginning of injection was always reflected as a pulse on electrodes in the perturbed zone. Increment in injection rate was also identifiable yet not as evident as injection start. The spam of injection is usually reflected by electrical anomalies that differ from what should be inherent drift. When comparing signals between different electrodes, higher voltages were obtained in smallest electrodes, probably indicating a relation with chemical inertia.

Non-reproducibility of results was due to erratic behaviour of gas in porous media. Degassing path during injection continuously migrated in time alternating between accumulation and leakage. At the considered scale, flow paths of gas reaching the electrodes varied heterogeneously, making almost impossible any computer modelling. In the same sense, terms that compose SP signals could not be quantified. Due to the scale we are working, we cannot state results to be obtained when applied the technique on field scale. Further research has to be done for assessing feasibility of applying surface SP monitoring at field scale, which is much larger than the representative elementary volume. At laboratory scale, the relation is the opposite for being smaller than the representative elementary volume.