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# $CO_2$FieldLab project. Near-surface downhole electrical resistivity monitoring for $CO_2$ shallow injection at the Svelvik ridge (Norway).

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The $CO_2$FieldLab shallow injection experiment is a collaborative effort aimed at developing, verifying, and evaluating near-surface monitoring techniques for geological sequestration of $CO_2$. The objective is to create a downhole leakage of $CO_2$ in order to demonstrate whether existing monitoring techniques have the ability to detect and quantify the $CO_2$ loss. The $CO_2$FieldLab project associates collaboration from several research groups and organizations (SINTEF, NGI, BRGM, BGS, CNRS, imaGeau and Schlumberger). For this, the field Laboratory for monitoring $CO_2$ migration and leakage was established in Holocene deposits of the Svelvik ridge, located in the Drammensfjord 50 km south of Oslo (Norway). It is a glaciofluvial-glaciomarine terminal deposit formed during the last deglaciation. The depth to the bedrock is located between 300 and 400 m. The central part of the ridge is aerially exposed up to 70 m above sea level, constituting a phreatic aquifer. The characterization phase and associated modelling suggest that the site is suitable for studying both gas migration and leakage at shallow depths. The shallow aquifer (down to 50 m) consists in a relatively homogeneous sand body with a depositional dip of about 10° to the North.

The shallow injection experiment took place in September of 2011 and consisted in an injection of $CO_2$ at a depth of 20 m from a 45° inclined well. The purpose of this phase was to simulate a point source leakage, which could possibly occur due to failure of a deep well completion. A total mass of 1.67 ton of $CO_2$ was injected over a period of 6 days. The water table was located at 60 cm depth during the experiment and a transition from fresh to salt pore water was found below 12 m depth. An integrated set of surface and downhole strategies was deployed across a 64 m2 square monitoring area: cross-hole radar, water and gas phases physico-chemical parameters (BRGM); multi-hole electrical ALERT system (BGS), $CO_2$ concentration in soils and gas flux measurements (BGS); WestBay completion for pressure monitoring and fluid sampling (Schlumberger); permanent downhole electrical resistivity observatory (imaGeau); time-lapse downhole induction and sonic logging (CNRS) All monitoring holes were drilled and equipped down to 20 m depth. The data recorded by CNRS and imaGeau are presented here.

Downhole electrical resistivity monitoring identified a couple of conductive clouds due to $CO_2$ dissolving into pore water. A first one appeared few hours after injection below 9 m, and a second one appeared later at about 6 m suggesting progressive upward migration of the injected $CO_2$. Near the base of the monitoring hole and to the opposite, an increase in resistivity was obtained over time from repeated induction logging. This gradual conductivity decrease is coherent with progressive $CO_2$ dissolution within the pore fluid in a zone of transition to sea water found from 12 m depth. The formation fluid sampling is next to confirm this hypothesis.