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# $CO_2$ Field Laboratory at Svelvik Ridge: Site characterization after the first injection experiment

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The safety and acceptance of $CO_2$ storage will depend on the ability to detect and quantify $CO_2$ within and outside the storage complex. To determine sensitivity of $CO_2$ monitoring systems with respect to $CO_2$ distribution and leakage detection, the $CO_2$ Field Lab project comprises two controlled $CO_2$ injection tests in the shallow (100-300 m) and very shallow (20 m) subsurface of the glacial deposit that forms Svelvik ridge, 50 km south of Oslo. The $CO_2$ displacement in the subsurface and at the surface has and will be monitored with an exhaustive set of techniques. Iteratively, observations and flow modeling will provide frequent updates of the $CO_2$ distribution. The results will be upscaled to assess monitoring systems and requirements with the ultimate objective to provide guidelines to regulators, operators and technology providers for monitoring systems.

The formation that comprises the laboratory is a glaciofluvial-glaciomarine terminal deposit formed during the Ski stage of the Holocene deglaciation. Nearby outcrops show that the formation is channeled and variably laminated with a significant variation in grain size and structure. Prior to the injection experiments, the site was characterized including 2D seismic and electric surveys, the drilling, logging and sampling of a 330 m deep appraisal well, core and flow line sample analyses, ground penetrating radar (GPR), a hydrodynamic appraisal, and geochemical and soil gas baseline surveys. These data were used to populate a geomodel. Flow modeling of the plume development included some variability in permeability and anisotropy, and various injection scenarios. Accordingly, the 20 m injection experiment was conducted in fall 2011 with a monitoring plan designed to spatially and temporally monitor the expected plume development. The monitoring equipment was thus distributed around the 20 m deep injection point of an inclined well. It included seven 6 m deep monitoring wells equipped with resistivity, sonic and geochemical logging tools, with GPR, and water samplers. Surface monitoring included stationary and mobile tools for geochemical analyses of ground water, soil and atmospheric gas. Even though the trajectory of migrating $CO_2$ deviated somewhat from the predictions, most stationary monitoring techniques picked up some trace of the $CO_2$ plume. The surfacing $CO_2$ flow was measured most precisely since the mobile surface stations were (re-)located over the leakage areas.

After the injection test, numerous sediment samples were taken at various depths and locations around the injection point. Together with the monitoring results, these data are used to better characterize the site and to update the geological and flow model for improved interpretation of the experiments. The results show that accurate information on the stratigraphic variability is of outmost importance for understanding possible pathways of $CO_2$ in the shallow subsurface.