Svelvik CO_2 Field Lab: A small-scale laboratory for development of equipment and CO_2 monitoring techniques

C. Ringstad[1], M. Jordan[1], P. Eliasson[1], A.-A. Grimstad[1], K. Hagby[1]
C. Schmidt-Hattenberger[2], W. Weinzierl[2], B. Wiese[2]
A. Wüstefeld[3]
[1]SINTEF Industry, Trondheim, Norway
[2]GFZ, German Research Centre for Geosciences, Potsdam, Germany
[3]NORSAR, Kjeller, Norway
Corresponding author's e-mail address: cathrine.ringstad@sintef.no

Keywords: Storage, site screening and site monitoring

ABSTRACT

A small-scale CO_2 field laboratory was established at Svelvik, Norway, by the SINTEF-coordinated CO2FieldLab project in 2010 (Bakk et al., 2012). The test site is currently being upgraded through the ECCSEL (European Carbon Dioxide Capture and Storage Laboratory Infrastructure) consortium and will be available to research projects worldwide when the upgrade is completed in May 2019.

The test site occupies a non-active part of a sand and gravel quarry, located in a glaciofluvial – glaciomarine environment. The upper glaciofluvial layer extends from the surface down to about 30 m, with heterogeneous sand and gravel. Below, in the glaciomarine environment down to the basement at 330 m, heterogeneous (and possibly varved) alternating layers of sand, silt and clay exists (Mørk et al., 2014).

Due to its size, the controlled environment (known "ground truth"), and the potential of repeatable experiments, the field laboratory will provide excellent possibilities to develop and test technologies and equipment required for large-scale CCS applications in a rapid and cost-efficient manner.

The test site consists of an injection well and four monitoring wells covering a square of about 50 m with the injection well at the center. The injections will be performed in the existing Svelvik #2 well at 64-65 m depth. A pumping test in 2013 showed that the layer is suitable for CO_2 injections with a permeability of approximately 123–170 mD (Bartcuz, 2013).

Due to its shallow depth, CO_2 will be injected at Svelvik in gaseous phase. However, the main geophysical properties relevant for CO_2 monitoring, (compressional wave velocity, resistivity and density) display a similar behaviour for gaseous and supercritical CO_2. In addition, dissolved CO_2 should be distinguishable from both brine and a mixture of brine and CO_2. Therefore, we expect that method development and testing at Svelvik will be relevant for deeper storage, where CO_2 is in a supercritical phase.

The monitoring wells will be approximately 100 m deep, covering depths that are deeper than the injection layer. Fiber-optic cables for distributed acoustic (DAS), strain (DSS) and temperature sensing (DTS) will be installed permanently behind casing in addition to electrical resistivity tomography (ERT) electrodes and cables in order to facilitate cross-well monitoring. PVC casings will be used since traditional steel casings would prevent reliable studies of geoelectrical methods.

Both straight and helical DAS fibers will be installed in all four monitoring wells. The combined sensitivities of straight and helical cables will enable recording of P- and S-waves and will improve the cross-well illumination compared to straight fibers alone. Pre-installation modelling is performed to find the optimum wrapping angle of the helical fiber with respect to coverage and detectability.

Due to their sensitivity with respect to pore fluid changes (water/gas), geoelectrical methods have been proven as a suitable technique to detect and track CO_2 migration in shallow aquifers (Auken et al., 2015). All monitoring wells are therefore equipped with permanent electrode arrays of equidistant spacing, comprising 16 electrodes per borehole and based on spiraglider centralizer design. Such a cross-well arrangement guarantees a reasonable coverage of the CO_2 signature in the subsurface and could provide information about preferential pathways.

Since the main purpose of the Svelvik CO_2 Field Lab is to enable and support the development of methods to improve the quantification of pressure and saturation during CO_2 monitoring, the knowledge of the "ground truth" is essential. Downhole sensors for ground truth monitoring will also be installed behind casing and include measurements of pressure, CO_2 concentration, and salinity.

Since the permanent installation of fiberoptic cables, electrode arrays and "ground truth" sensors will be behind casing, the interior of the wells will be available for non-permanent monitoring equipment. For instance, seismic P- and S-wave borehole sources may be used together with 3C borehole receivers, creating high resolution seismic cross-well data sets. The colocation of conventional seismic receivers and DAS cables will provide additional opportunities for the development and testing of fibre-optic cables and processing techniques for this type of data. The inside of the wells will be also available for development and testing of future monitoring systems.

The distance between the injection- and monitoring wells have been optimized with respect to coverage and sensitivity of the DAS system, and such that the expected distributions of CO_2 saturation and pressure between the four monitoring well locations can be kept as constant as possible during the cross-well monitoring.

The new monitoring infrastructure at Svelvik is currently being designed and is planned to be operational in May 2019.

Auken E., Doetsch J., Fiandaca G., Christiansen A.V., Gazoty A., Cahill A. G., Jakobsen R., 2014: "Imaging subsurface migration of dissolved CO_2 in a shallow aquifer using 3-D time-lapse electrical resistivity tomography". Journal of Applied Geophysics, 101, 31-41.

Bakk, A., Girard, J.-F., Lindeberg, E., Aker, E., Wertz, F., Buddensiek, M., Barrio, M. and Jones, D., 2012: "CO2 Field Lab at Svelvik ridge: Site suitability". Energy Procedia 23, 306 – 312.

Bartucz., D., 2013: " Final Report on Well Testing in Svelvik Well#2 for SINTEF". Deliverable D2-3-1A-1, CO2FieldLab project.

Mørk, A., Barrio, M., Buddensiek, M., Grimstad, A.-A., Lindeberg, E., Bakk, A., Rendall, H., and Ruden, F., 2013: "CO2FieldLab: Field experience with monitoring and safety assessment of CO_2 migration in shallow subsurface". NGF Abstracts and Proceedings, no. 1, 2013