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Geophysical monitoring of near surface CO_2 injection at Svelvik - Learnings from the CO_2FieldLab experiments.

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A CO_2 migration field laboratory for testing monitoring methods and tools has been established in the glaciofluvial-glaciomarine Holocene deposits of the Svelvik ridge, near Oslo (Norway). At the site, feasibility, sensitivity, acquisition geometry and usefulness of various surface and subsurface monitoring tools are investigated during controlled CO_2 injection experiments. In a first stage, a shallow CO_2 injection experiment was conducted in September 2011.

Approximately 1700 kg of CO_2 was injected at 18 m depth below surface in an unconsolidated sand formation. The objectives of this experiment were to (i) detect and, where possible, quantify migrated CO_2 concentrations at the surface and very shallow subsurface, (ii) evaluate the sensitivity of the monitoring tools and (iii) study the impact of the vadose zone on observed measurements. Results showed that all deployed monitoring tools (for surface and near-surface gas monitoring, subsurface water monitoring and subsurface geophysical monitoring) where able to detect the presence of CO_2 even though the CO_2 plume did not migrate vertically as expected in what was thought to be an homogeneous unconsolidated sand structure. The upper part of the site revealed to be more heterogeneous than expected, mainly due to the highly variable lamination and channelling of the morainic sediments and to the presence of pebble and cobble beds sporadically showing throughout the deposits.

Building on the learnings from the 18m depth injection experiment, a second experiment is being planned for a deeper injection, at a depth of 65m. Re-processing of the appraisal 2D multi-channel seismic with state-of-the-art processing techniques, like Linear Radon coherent and random noise attenuation and Full Waveform Inversion followed by pre-stack depth migration, corroborate the presence of heterogeneities at the near surface. Based on the re-interpreted seismic sections, a more realistic 3D geomodel, where the complex topography of the site is taken in to account, is derived to serve as the basis for a new feasibility study. Advanced forward modelling for both seismic and electromagnetic waves is performed to investigate effects like scattering at the shallow subsurface, attenuation and anisotropy and possible ways of mitigating those effects on the monitoring capabilities are proposed.

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