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Microseismic monitoring and velocity model building at the Longyearbyen CO_2-Lab, Svalbard

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The Longyearbyen CO_2 storage lab project addresses the problem to turn Svalbard into a CO_2 neutral community. The project has now confirmed that an injective reservoir (800-1000 m depth) and a sealing cap rock section exist around Longyearbyen, and will proceed towards demonstration and monitoring studies of sub surface CO_2 storage over time. The progressive construction of the Longyearbyen CO_2 storage lab is currently addressing detailed properties and geometry of the reservoir. Liquids other than CO_2 have been used in this initial phase (water, brine, gel). The reservoir below Longyearbyen is considered physically open, and, therefore, will likely experience drift of the injected CO_2 towards the Northeast, through gradual mixing and expulsion of saline groundwater. This offers a unique opportunity for studying the behavior of CO_2 in subsurface saline aquifers. Four wells have been drilled so far and several new monitoring wells are planned for this purpose. In this study, we try to use induced seismicity to monitor the injection fluid in the test site. A precise estimation of the location and magnitude of the microearthquake will be important to investigate the link between the injection and the sudden stress release as a microearthquake.

In August 2010 a fluid injection experiment was carried out at the CO_2 lab. In parallel, a microseismic monitoring network was deployed close to the injection well. The network consists of a 5-level string of 3-component geophones in a vertical observation well, with 50m distance between the instruments and a maximum depth of 294 meters. In addition, three shallow boreholes of 12 m depth have been drilled at about 500 m distance to the injection well. These additional surface stations are intended to provide more accurate locations for microearthquakes that are large enough to be recorded at the surface. Approximately 17 hours after the 5-days water injection test (from 20th to 25th August, 2010), a relatively strong microseismic event has been recorded at all 8 geophones and is located close to the injection well. An accurate location of this seismic event was not possible yet, due to high uncertainties in our velocity model, affecting mainly the depth of the location. In addition, we use the waveforms of this event as a template (i.e. the “master” event) and search for other events with similar waveforms at lower signal-to-noise ratios based on the matched filter method. After scanning through 78-days of continuous data (10th August to 26th October, 2010), we have detected seven events, with a statistically high correlation coefficient from network average.

In order to record any potential seismicity during new injection tests, additional two surface geophones are deployed near the injection well to improve constraining the microearthquake locations. Further improvements on the velocity model are also ongoing, using 2D seismic lines, well logs, VSP and additional explosions at the surface observed with the vertical array. Most improvement of the velocity model is expected in the shallow part of the model, directly enhancing the location accuracy and help to track fluid injection interpreted from microseismicity.