Effects of geological heterogeneity on fluid distribution and pressure propagation in a shallow, stacked aquifer system at the ECCSEL Svelvik CO2 Field Lab, Norway

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The ECCSEL Svelvik CO2 Field Lab is a test site for shallow CO2 injection operated by SINTEF, where the aim is to improve monitoring techniques and extend the knowledge base for storing CO2 underground in deep saline aquifers as a climate mitigation strategy. The test site is located in a Holocene ice contact deposit near Drammen in the Oslofjord. Test injection is possible at 65 m depth. There has been extensive research focused on increasing the understanding of monitoring methods for deep injection of CO2 and the (short term) migration of CO2, based on experiments performed in this shallow aquifer. To maximize the value of data collected in the shallow experiments a solid geological model is fundamental to enable prediction of how water and gas will behave in the reservoir. Various thicknesses of reservoir layers and degree of internal heterogeneity (clinoforms, unconformities, faults) are observed. Analysis of new data from wells (cuttings sediment samples, wire line logs) and comparison with existing data (e.g. seismic lines, georadar profiles) indicate upwards shallowing and upwards freshening trends through the stratigraphic succession, i.e. variation in palynomorph assemblages. Groundwater flux and aquifer connectivity was evaluated through comparison of water chemistry, noble gas content (the ICO2P project) as well as resistivity- and pressure-logging in upper (fresh) and lower (saline) parts. Analysis of the tidal pressure signal in the deep part of the aquifer gives an indication of the degree of communication between the layers of the aquifer. The areal extent of (semi-)sealing layers of mud, as well as intra-reservoir geological heterogeneity (inclined, graded sandy beds with thin, muddy lamina) affects CO2 distribution in the test reservoir, and is likely to lead buoyant fluids along preferential flow paths. Facies models include North-South progradational patterns and are represented in anisotropic property distributions (Petrel - Schlumberger) for fluid flow simulations (Eclipse - Schlumberger). Predicted CO2 flux is towards the North, below what appears to be locally extensive flow baffles. Integrated data analysis has improved the geological understanding of the Svelvik stacked aquifer system, which may be utilized in future applications to improve monitoring methods for safe large-scale CO2 storage.
