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Combined Seismic and Geoelectric Modeling of CO2 Plumes in Deep Saline Reservoirs

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SUMMARY

Our geophysical task within the multidisciplinary project CO2 MoPa (modelling and parameterisation of CO2 storage in deep saline formations for dimensions and risk analysis) is to estimate the sensitivity and the resolution of reflection seismic and borehole geoelectrical time-lapses in order to determine the propagation and development of the CO2 reservoir in the subsurface formations.
Compared with seismic, electric resistivity tomography (in boreholes, BRT) has lower mapping resolution, but its permanent installation and continuous monitoring can make it an economical alternative or complement. Applications of both methods to quantify changes of intrinsic aquifer properties with time are justified by the lower seismic velocity, and high electric resistivity of CO2 in comparison to pore brine.
We present here synthetic modeling results on almost realistic scenarios similar to that of deep saline formations of the German Basin (candidate for CCS). For this basin the study focuses on effects of parameters related to depths (1-3km, temperature gradient of 30°C/l/km, petrophysics (TDS of 100g/km, porosity of ≥0.15), plume dimensions (≥ some meters)/saturations (30-80%) and data acquisition, processing and inversions.
Both methods show stronger effects with increasing brine salinity, CO2 reservoir thickness, porosity and CO2 saturation in the pore fluid. They have a pronounced depth dependence due to the pressure and temperature dependence of the velocities, densities and resistivities of the sequestration targets (host rock, brine and CO2). Increasing depth means also decreasing frequencies of the seismic signal and hence weaker resolution. Because of the limited thickness of the CO2 reservoir expected in this basin, the reflections from its top and bottom will most likely interfere with each other, making it difficult to determine the exact dimensions of the reservoir. In BRT, the resulting resistivity resolution and anomaly magnitudes are inversely proportional to the salinity and temperatures and directly proportional to CO2 saturation and dimensions. The sensitivity of the seismic method to CO2 saturation changes is most pronounced for low CO2 concentrations while the geoelectric method has a higher sensitivity at high concentrations and/or lower salinity.

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