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Seismic and geoelectric monitoring of CCS – parameter studies in simplified and realistic scenarios

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The multi-disciplinary research project "CO_2-MoPa" (**mo**deling and **pa**rametrization of $\mathbf{CO_2}$ storage in deep saline formations for dimension and risk analyses) deals with the parametrization of virtual subsurface storage sites to characterize rock properties with modeling of processes related to CCS in deep saline reservoirs. The geophysical task is to estimate the sensitivity and the resolution of reflection seismic and geoelectrical time-lapses in order to determine the propagation of CO_2 within the sediments and the development of the CO_2 reservoir. Compared with seismics, electric resistivity tomography (ERT) in boreholes has a lower resolution, but its permanent installation and continuous monitoring can make it a complement.

In the first part of this study, we use simplified models to investigate the effects of selected parameters or their combinations on seismic and geoelectric properties and how this affects monitoring possibilities with reflection seismics and ERT (in boreholes). In the second part, we apply the acquired experiences on a realistic subsurface scenario in the North German Basin (Wagrien, Eastern Holstein). We obtain the necessary parameters from other CO_2-MoPa sub-projects (e.g. geochemistry, geology) and from literature. The study focuses on effects of parameters related to depths, petrophysics, plume forms, dimensions and saturations, reservoir salinity, as well as on data acquisition, processing and inversions. Both methods show stronger effects with increasing brine salinity, CO_2 reservoir thickness, porosity and CO_2 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 CO_2). While the lateral extent of a thin CO_2 reservoir can be determined rather accurately with seismics, the reflections from its top and bottom interfere with each other, making it difficult to identify the exact vertical dimensions of the reservoir. This is especially true in the more realistic scenario with several interfering reflectors. In BRT, the resulting resistivity resolution and anomaly magnitudes are inversely proportional to the salinity and temperatures and directly proportional to CO_2 saturation, dimensions, and aspect ratio. The sensitivity of the seismic method to CO_2 saturation changes is most pronounced for low CO_2 concentrations while the geoelectric method has a higher sensitivity to concentration changes at high concentrations. A combination of the two geophysical monitoring techniques can thus be advantageous, especially in the estimation of the mass of the CO_2 anomaly.

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