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Application of the reflection seismic method for monitoring CO_2 injection in a deep saline aquifer in Baltic Sea: A modeling study

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Time-lapse reflection seismic methods have proven effective for detecting and monitoring the injection and spreading of geologically stored CO_2. These methods are based on interpreting changes in the media's elastic properties that result from replacing the native saline water by the injected CO_2, which in turn affects the seismic velocities of the media. Since applications of these methods in the field are expensive and the interpretation process is time consuming, pre-study investigations should be done in order to determine whether or not reflection seismic surveys can successfully be applied to monitor the CO_2 plume in the case of interest.

In the present study, we model CO_2 injected into a deep saline aquifer based on a structure situated in the south-western part of the Baltic Sea. The injection was numerically simulated using TOUGH2/ECO$_2$N modeling, to determine the CO_2 saturation distributions at different times. A radial-symmetric modeled with homogeneous and isotropic properties was assumed and two different injection rates were studied and the results were analyzed at different times after the start of the injection.

The saturation and density values resulting from the TOUGH2 simulation were converted to seismic velocities using the Biot-Gassman model. A synthetic velocity model was built based on these models and synthetic seismic response fields before and after injection were generated. Our results show that the amplitude changes in the seismic response are detectable even for small amounts of injected CO_2 while noticeable signs of velocity pushdown as a signature of the CO_2 substitution could only observed if the injection rate is high enough.