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Physics, seismic numerical modeling and tomographic inversion for monitoring CO_2 geological storage.

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There is evidence that, during the last 150 years, the increased concentration of greenhouse gases has increased the atmospheric temperature by 0.3 – 0.6 ºC (Ledley et al., 1999). Geological sequestration of CO_2 is an immediate option to reduce the emission of this gas into the atmosphere. The main possibilities are injection into hydrocarbon reservoirs, saline aquifers and unmineable coal mines.

We present a petro-elastical and numerical-simulation methodology to compute synthetic seismograms of CO_2 bearing rocks, with the purpose of defining the sensitivity of the seismic response under the changing concentration of this gas during injection. Moreover, the tomographic inversion of seismic data, together with the petro-elastical model, allows to estimate the distribution and concentration of CO_2 during and after the injection phase.

The petro-elastical equations model the seismic properties of reservoir rocks saturated with carbon dioxide, methane, oil and brine as a function of the *in situ* pore pressure and temperature. The gas acoustic properties are computed with the Peng-Robinson equation of state (Peng and Robinson, 1976), and the oil and brine properties with empirical relations given by Batzle and Wang (1992). Gas viscosities are computed with the Lohrenz-Bray-Clark model (Lohrenz, Bray and Clark, 1964).

The numerical simulations are performed with a poro-viscoelastic modeling code based on Biot's theory, where viscoelasticity is described by generalizing the solid/fluid coupling modulus to a relaxation function. Using the pseudo-spectral method, which allows general material variability, a complete and accurate characterization of the reservoir can be obtained (Carcione, 2001).

Reflection tomography is used to compute the seismic-wave velocity field. The method is based on Fermat's principle and represents the earth an a blocky medium, with reflecting curved or dipping interfaces. Böhm et al. (1999) and Vesnaver and Böhm (2000) have described the method.

The methodology is applied to the Atzbach-Schwanenstadt gas field, a site for potential underground CO_2 sequestration. This field, located in Upper Austria and operated by Rohöl-Aufsuchungs AG, is one of the four potential sites considered within the EU-funded CASTOR project (Polak et al., 2006). Various scenarios have been considered for the simulation and related tomographic inversion, confirming the suitability of the methodology for CO_2 monitoring.

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