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Property modelling of a potential CO_2 storage site using seismic inversion

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Within the scope of reservoir modelling for a potential carbon dioxide (CO_2) storage site in northern Spain, a static model was built to integrate the available seismic and well data. These were both pre-existing data and new data acquired during an extensive appraisal campaign, aimed at characterizing the target storage site's geology.
Interpretation of six different seismic surveys and of petrophysical logs from seven wells was conducted prior to the modelling in order to constrain the reservoir structure and properties over a 4,000 km2 study area. Seismic interpretation and velocity modelling were conducted in parallel with the drilling of the wells and confirmed the high reliability of the structural model. Three-dimensional (3D) interpretation also improved the understanding of the fault network and the geometry of the sealing formations. Well log interpretation allowed a re-evaluation of the petrophysical properties in the basin, notably porosity and permeability, which were initially estimated from offset wells located more than 50 km from the CO_2 geological storage site.
A significant amount of additional input to the static model was provided by the full-stack inversion of three newly acquired seismic surveys, two of which are two-dimensional (2D) and one 3D. The acoustic impedance (AI) volumes calculated through this process allowed us to constrain porosity and permeability distributions in the property model. The inversions, run separately for each seismic survey, were in very good agreement with each other. The results were compared with the regional geology of the site, allowing the identification of basin-wide trends in the acoustic impedance volumes that correlate to well and outcrop data. The agreement with the prior conceptual geological model, based on offset data, is good.
The 2D impedance lines were interpolated for use in property modelling, while AI volume from the 3D seismic was used directly, as a trend for the population of the porosity model, which in turn was used as a guide for the distribution of permeability. This allowed better control on the property distribution compared to a purely stochastic approach, and resulted in a more realistic model.
Notably, within the target site, high porosity and permeability zones could be identified within the reservoir formation (a heterogeneous fluvial sandstone with shaly intercalations); these zones could now be targeted for the placement of the potential injection site.