

Constraining CO₂ simulations by coupled modeling and inversion of electrical resistance and gas composition data

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Abstract:

This study investigates how model predictions of subsurface CO₂ migration can be constrained and improved with time-lapse electrical resistance tomography (ERT) data for a pilot experiment located at Cranfield, Mississippi. To this end, we first invert the time-lapse ERT dataset using structurally constrained and unconstrained inversions. With the ERT time-lapse inversions, we image the increasing supercritical CO₂ saturation in the reservoir and find that including the reservoir boundaries as structural constraints significantly improves the images. We then use ERT-derived changes in subsurface electrical resistivity along with gas composition data to constrain and calibrate hydrological models. We use the inversion framework iTOUGH2 and test several simplified conceptual models for the reservoir. Our analysis shows that the reservoir response cannot be adequately reproduced with a radial model; rather, the system exhibits 1D behavior. A model with three 1D layers, whose permeability values and width were estimated by inversion, is able to explain the ERT and gas composition data. Derived permeabilities agree with those from core measurements and a well test. Despite high noise levels, the ERT data provided crucial information in the inversion thanks to its high sensitivity at the inter-well scale, its stabilizing effect on the inversion, and the direct link it provides between electrical resistivity and CO₂ saturation.

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