ROCK PHYSICS BASED DOUBLE DIFFERENCE INVERSION FOR CO₂ SATURATION AND POROSITY AT THE CRANFIELD CO₂ INJECTION SITE

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ABSTRACT

Large-scale subsurface injection of CO₂ has the potential to both reduce emissions of atmospheric CO₂ and improve oil recovery. Studying the effects of injected CO₂ on the elastic properties of the saturated reservoir rock can help improve long-term monitoring effectiveness and accuracy at locations undergoing CO₂ injection. This study uses two vintages of existing 3D surface seismic data and well logs to probabilistically invert for the CO₂ saturation and porosity at the Cranfield reservoir using a double difference approach. The first step of this work was to calibrate the rock-physics model to the well log data. Next, the baseline and time-lapse seismic datasets were inverted for acoustic impedance, Ip, using a high-resolution basis pursuit inversion technique. Reservoir porosity was derived statistically from the rock-physics model based on the Ip values from the impedance estimates derived from the baseline survey. The porosity estimates were used in the double difference routine as the fixed initial model from which CO₂ saturation was then estimated from the time-lapse Ip data. Porosity was assumed to remain constant between survey vintages; therefore, the changes between the baseline and time-lapse Ip data may be inverted for CO₂ saturation from the injection activities using the calibrated rock-physics model. Comparisons of inverted and measured porosity from well logs indicate quite accurate results. Estimates of CO₂ saturation show less accuracy than the porosity estimates.
Panel a shows the estimated CO\textsubscript{2} saturations values as calculated from an RMS average of the top three samples in the reservoir. Panel b shows the RSTD values that are associated with the CO\textsubscript{2} values shown in panel a. In both panels inline number is shown on the vertical axis while the x-axis shows cross-line number. The white dots are injection wells 28-1 and F-1. Additional injection wells are shown by the gray dots. Panel a is colored to CO\textsubscript{2} saturation with red indicating a pure CO\textsubscript{2} pore fluid and blue indicating a pure brine pore fluid. In panel b red indicates a higher RSTD value and higher potential error in the value, and blue indicates a lower RSTD value and lower potential error. The scale is the same for both panels.