

Modeling Fluid Composition in CO₂ Saturated Sandstone Using a Statistical Rock Physics Approach, Cranfield Field, Cranfield, MS

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Analysis of the effects of injected CO₂ on the seismic response of reservoirs is important because it can provide improved characterization and monitoring of sites undergoing CO₂ injection for both utilization and storage purposes. In this study we used two different inversion schemes to better understand the effect of CO₂ saturation on the elastic parameters of the Cranfield reservoir in to which over 3.4 million tons of CO₂ have been injected. The first was statistical classification to determine which combination of elastic parameters were best discriminated CO₂ saturation. The second scheme used that combination to invert jointly a rock physics model for CO₂ saturation and porosity. This determines the reliability of the chosen parameters and the rock physics model for discriminating fluid composition and correlated properties. For the first scheme, we calibrated a rock physics model to well data from the Cranfield reservoir interval. We then performed fluid substitution to model density and velocity logs for different in situ CO₂ saturations. From the modeled synthetic logs, we computed bivariate probability density functions (PDFs). The modeled logs were statistically classified to these PDFs to determine which elastic parameters and parameter combinations best discriminated fluid composition. P-impedance and the V_p/V_s ratio was the best combination. The logs of the highest performing parameter combination were then input into an inverted rock physics model to generate modeled logs of CO₂ saturation and porosity. In the second step, this combination was used to invert the contact cement rock physics model for CO₂ saturation and porosity. This rock physics model provides a quantitative link between elastic parameters and the lithology and fluid saturation of the reservoir, and through inversion, can be used to model CO₂ saturation and porosity. Results from the second phase of this study showed that the model was able to predict porosity and an absence of in situ CO₂ with a relatively high degree of accuracy. However, when some CO₂ was present, the ability to discriminate among varying CO₂ concentrations was reduced. The two-step approach taken here estimates the relationship and associated uncertainty between the elastic properties and the reservoir properties of interest at the well log scale. Future work may use these estimates along with high-resolution seismic data to provide spatial distribution of injected CO₂.

Keywords: Rock Physics, Carbon Capture Utilization and Storage, Geophysics, Cranfield, Joint Inversion