DOUBLE DIFFERENCE ROCK PHYSICS INVERSION FOR POROSITY AND PORE FLUID AT THE CRANFIELD INJECTION SITE

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ABSTRACT
Studying how injected CO$_2$ affects the seismic response of reservoir rocks is important because it can improve subsurface characterization where CO$_2$ injection is taking place. This study uses two vintages of 3D surface seismic data and well logs to invert probabilistically the porosity and CO$_2$ saturation at the Cranfield reservoir using a double difference approach. Initially the well logs were used to calibrate a rock physics model. Next the baseline and time-lapse seismic data were inverted for P-impedance using a basis pursuit algorithm. The baseline P-impedance volume was used in conjunction with the calibrated rock physics model to generate probabilistic outputs of porosity. The porosity estimates were used in the double difference routine as the starting model to estimate CO$_2$ saturation from the time-lapse P-impedance data. Assuming that porosity was constant, the time-lapse P-impedance data was inverted for CO$_2$ saturation using the calibrated rock-physics model. Comparisons of inverted and measured porosity from well logs show accurate results. At the surface seismic scale, inverting the baseline surface seismic impedance data for porosity provided accurate reservoir porosities. Pore-fluid composition was also estimated but with reduced accuracy relative to the porosity estimates. The pore fluid estimates currently give higher CO$_2$ saturations than expected. This methodology is able to discriminate between areas containing CO$_2$ and those that do not. Increasing the sensitivity of this approach to varying concentrations of CO$_2$ dissolved in brine requires further study.
The top of the reservoir colored to pore fluid composition. Red indicates pure brine and blue indicates pure CO$_2$. The white dot located at inline 1060 and cross line 290 is the location of CO$_2$ injection for EOR purposes, and the white dot at inline 1031 and cross line 197 is the location of well F-1.