The Seismic Response to Injected Carbon Dioxide: Comparing Observations to Estimates Based Upon Fluid Flow Modeling

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Abstract

Time-lapse seismic amplitude differences and travel time shifts, obtained while monitoring enhanced oil recovery at Cranfield, Mississippi, reveal coherent changes that are associated with the injection of carbon dioxide. Rock physics modeling highlights the importance of the oil, brine, and gas content of pore fluids prior to the injection of carbon dioxide. For example, compressional velocity changes due to the injection of carbon dioxide can drop from 300 m/s to less than 100 m/s as the percentage of oil increases from 1% to 50%. Predictions based upon a new technique for modeling wave propagation in a poroelastic medium containing an arbitrary number of fluids, coupled with multicomponent numerical reservoir modeling at Cranfield, reproduce the general pattern of observed seismic amplitude changes and travel time shifts. In particular, time-lapse amplitude changes suggest a significant and widespread lowering of compressional velocities due to the injection of CO_2 into an aquifer bounding the oil rim of the reservoir. It appears that the large-scale variations in preexisting pore fluid content have a major influence on seismic velocity changes, even in the highly heterogeneous reservoir at Cranfield.