

Assessing sensitivity to well leakage from three years of continuous reservoir pressure monitoring during CO₂ injection at Cranfield, MS, USA

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Abstract:

Continuous reservoir fluid pressure monitoring is a technique being deployed and evaluated for monitoring CO₂ sequestration projects for storage integrity. Pressure data are known to reveal information about bulk reservoir properties and performance, and the pressure magnitude trajectory through time is commonly used as a metric for demonstrating numerical flow model conformance with observed injection history (i.e. pressure history match). Identification of well leakage using a pressure history approach can be difficult due to the subtle effects such leaks can have on the characteristic pressure magnitude evolution. Using a combination of theory, an analytically-derived synthetic reservoir pressure history example, and analysis of field pressure data, we develop a broadly applicable technique for analyzing reservoir pressure transients in continuous time series and illustrate how that technique can be used to quantify sensitivity to wellbore leakage in the field. Analysis presented here focuses on information provided by second derivative of the continuous pressure time series (d^2P/dt^2). We show that d^2P/dt^2 transients reveal consistent relationships with known (theoretical case) or induced (field case) pressure perturbations that are independent of prior pressure history, making them a very useful diagnostic tool for identifying and evaluating any observed transients of unknown origin (i.e. sudden well leakage events unrelated to injection schedule). To the degree that the onset of well leakage is expressed as a pressure transient similar to decreases in injection rates, we are able to identify the source functions (changes in flow rates from variable distances) that our gauges are (and are not) sensitive to. Observational data indicate that sensitivities in the field can be much lower than theoretical expectations, mostly a result of noisy and heterogeneous natural systems. Our analysis can be applied to other field scenarios with different reservoir properties for refining observation well placement design with predictable and quantifiable sensitivity.

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