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Using pulse testing for leakage detection in carbon storage reservoirs: A field demonstration

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Abstract

Monitoring techniques capable of deep subsurface detection are desirable for early warning and leakage pathway identification in geologic carbon storage formations. This work demonstrates the feasibility of a pulse-testing-based leakage detection procedure, in which the storage reservoir is stimulated using periodic injection patterns and the acquired pressure perturbation signals are analyzed in the frequency domain to detect potential deviations in the reservoir's frequency domain responses. Unlike the traditional well testing and associated time domain analyses, pulse testing aims to minimize the interference of reservoir operations and other ambient noise by selecting appropriate pulsing frequencies such that reservoir responses to coded injection patterns can be uniquely determined in frequency domain. Field demonstration of this pulse-testing leakage detection technique was carried out at a CO_2 enhanced oil recovery site—the Cranfield site located in Mississippi, USA, which has long been used as a carbon storage research site. During the demonstration, two sets of pulsing experiments (baseline and leak tests) were performed using 90-min and 150-min pulsing periods to demonstrate feasibility of time-lapse leakage detection. For leak tests, an artificial leakage source was created through rate-controlled venting of CO_2 from one of the monitoring wells because of the lack of known leakage pathways at the site. Our results show that leakage events caused a significant deviation in the amplitude of the frequency response function, indicating that pulse testing may be deployed as a cost-effective active monitoring technique, with a great potential for site-wide automated monitoring.