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Modeling of time-lapse seismic reflection data from CO_2 sequestration at West Pearl Queen Field

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Sequestration of CO_2 in depleted oil reservoirs, saline aquifers, or unminable coal sequences may prove to be an economical and environmentally safe means for long-term removal of carbon from the atmosphere. Requirements for storage of CO_2 in subsurface geologic repositories (e.g., less than 0.1% per year leakage) pose significant challenges for geophysical remote sensing techniques. The many issues relevant to successful CO_2 sequestration (volume in place, migration, leakage rate) require improved understanding of the advantages and pitfalls of potential monitoring methods. Advanced numerical modeling of time-lapse seismic reflection responses offers a controlled environment for testing hypotheses and exploring alternatives.

The U.S. Department of Energy has conducted CO_2 sequestration and monitoring tests at West Pearl Queen (WPQ) field in southeastern New Mexico. High-quality 9C/3D seismic reflection data were acquired before and after injection of ~2 kt of CO_2 into a depleted sandstone unit at ~4200 ft depth. Images developed from time-lapse seismic data appear to reveal strong reflectivity changes attributed to displacement of brine by CO_2.

We are pursuing seismic numerical modeling studies with the goal of understanding and assessing the reliability and robustness of the time-lapse reflection responses. A 3D time-domain finite-difference isotropic elastic wave propagation algorithm generates realistic synthetic data. With this capability, we examine how various types of errors and noise in the 4D data degrade the ability to image a deep CO_2 plume. Source/receiver sampling, subsurface illumination, correlated geologic heterogeneity, and static shifts are considered. As a result, we are able to make quantitative estimates of the tolerable errors for monitoring CO_2 injection at WPQ field. Future plans include incorporating 3D poroelastic wave propagation modeling into the analysis.

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