Modeling of Time-lapse Seismic Monitoring Data for Early CO_2 Leakage Detection Using Leakage Simulations at the FutureGen2.0 Site

Zan Wang*[1], Robert M. Dilmore[1], William P. Harbert[1], Lianjie Huang[2]
[1] National Energy Technology Laboratory, Pittsburgh, PA; [2]Los Alamos National Laboratory, Los Alamos, NM
* (zan.wang@netl.doe.gov)

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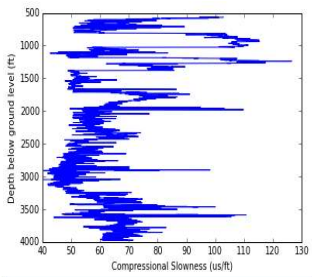
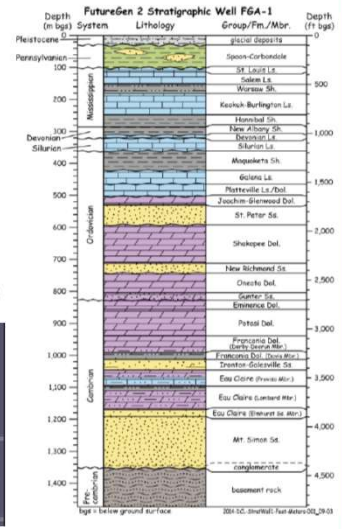
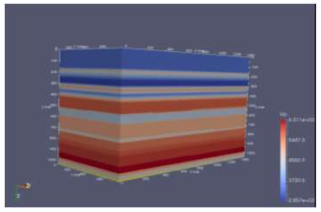
Construct seismic velocity model

❑ Background seismic velocity model (no leakage case)

Wireline log data (initial P- and S-wave slowness, density, elemental analysis lithology, etc.) from the stratigraphic borehole



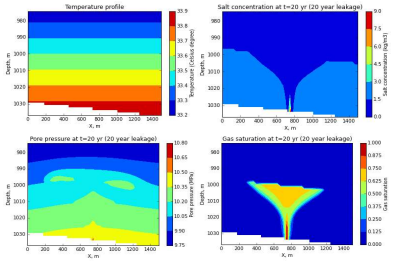




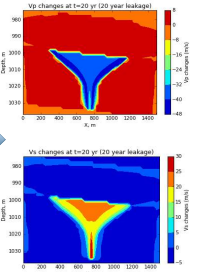
Constructed 3D initial seismic velocity model (from the ground surface to the bottom of the Ironton sandstone formation)

❑ Rock physics modeling: estimate seismic velocity changes for the simulated leakage scenarios

- 1% of total mass leaked over 20 years (0.22 MMT)
- Gassmann-Biot modeling for fluid substitution
- Hertz-Mindlin contact theory for pressure effects on dry-frame moduli

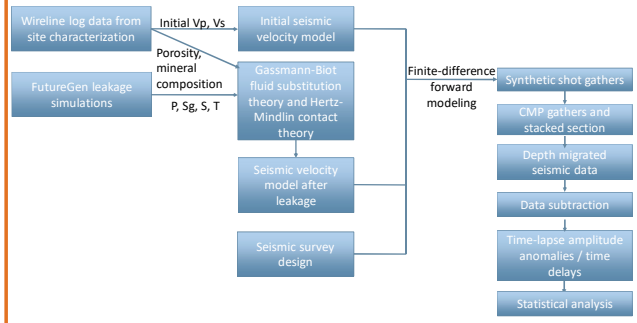


STOMP flow simulation results



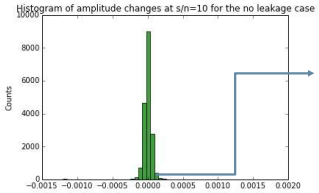
Seismic velocity model

Workflow of forward modeling and analysis of synthetic seismic data

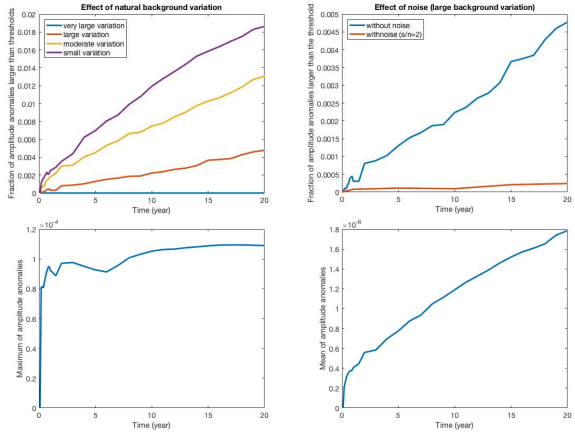


Infer CO_2 leakage using amplitude anomalies

- Characterize the natural background variation of seismic traces
- Statistical analysis on amplitude anomalies

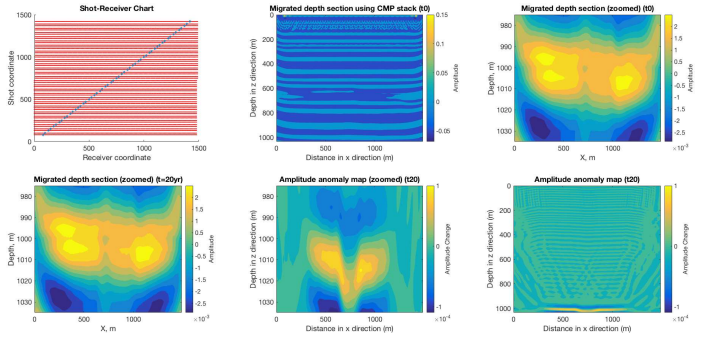


Detection threshold: 95th percentile
(For signal to noise ratios of 5, 10, 15, and 20, the detection thresholds are 1.505e-4, 7.506e-5, 4.963e-5, and 3.744e-5, respectively.)

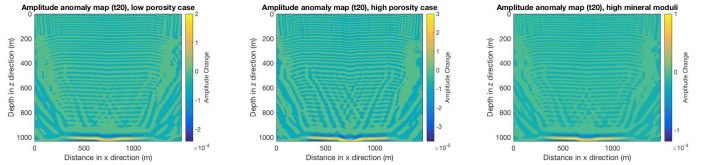


Modeling of 2D surface seismic monitoring data

Geometry: 55 shots and 297 receivers, evenly distributed along a 2D line.



❑ Sensitivity to porosity and elastic moduli of clay minerals



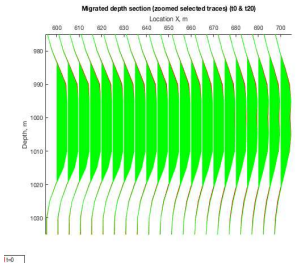
Discussion

❑ Seismic noises greatly reduce the likelihood of detecting the leakage.

❑ Changes in P-wave velocity and amplitude decrease with increasing porosity values.

❑ Changes in P-wave velocity and amplitude increase with increasing moduli of clay minerals.

❑ Amplitude anomalies vs. time delays



Acknowledgements

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