Monitoring CO_2 Injection with Seismic and EM Methods

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In a carbon conscious world steps are being taken to decrease the amount of CO_2 being released into the atmosphere. Geological sequestration has been proposed as a viable option for mitigating the vast amount of CO_2 being produced daily. Test sites for CO_2 injection have been appearing across the world to ascertain the feasibility of capturing and sequestering carbon dioxide. Geophysical methods developed for petroleum exploration play a crucial role in both characterizing the injection site and monitoring the subsurface pre- and post-injection. The subsurface environment is characterized pre-injection through seismic surveys and various well logging tools. The injection well and boreholes in the surrounding area utilize well logging as monitoring tools to track the movement of the CO_2 plume.

Our research utilizes numerical techniques to study the effectiveness of seismic and electromagnetic methods as a monitoring tool in the Ohio River Valley. The employed methods involve a finite difference seismic modeling code that is part of the Madagascar package, an open-source data processing and numerical experiments suite of programs. Seismic and electromagnetic simulation is conducted on a geological model that is representative of the subsurface in the Ohio River Valley. Specific interest is placed on the injection targets, Rose Run and Copper Ridge units, and the associated cap rocks, which are wide spread in the region. Modeling the effects that the injected supercritical CO_2 has on the velocity and density of the units, is showing the following: 1) a decrease in P-wave velocity until CO_2 saturation reaches 21% of pore space, 2) the P-wave velocity approaches original value after 21% CO_2 saturation, and 3) the bulk density of the formation linearly decreases by -0.0006 (g/cc/percent CO_2) as the CO_2 saturation increases. By incrementally raising the CO_2 saturation we illustrate the limits of seismic and electromagnetic methods for detecting and imaging a CO_2 plume in the Ohio River Valley.