SAND2010-0007C

American Geophysical Union Fall Meeting, 14-18 December 2009, San Francisco, California, USA

Poroelastic Seismic Wave Propagation Modeling of CO2 Sequestration Effects

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Long term geologic sequestration of carbon dioxide (CO2) is increasingly considered a viable approach for removing large amounts of excess carbon from the earth's surface environment. As CO2 is injected into a subsurface porous formation, it displaces (or mixes with) existing *in situ* pore fluids such as brine, oil, or methane. The seismic reflection and transmission responses of the formation depend on the degree of CO2 substitution. Additionally, geochemical reactions involving CO2 and mineral grains alter the bulk and shear moduli of the solid constituent and/or the matrix of the porous medium. In this study, we examine full waveform, wide-angle, amplitude *vs*. offset (AVO) responses of sandstone and carbonate layers. Synthetic seismic data are calculated with a 3D poroelastic wave propagation algorithm that solves Biot's governing system of thirteen coupled partial differential equations via an explicit, time-domain, finite-difference method. All of the common seismological phases (primary and multiple reflections, mode conversions, head waves, surface and interface waves) are generated with fidelity, provided spatial and temporal gridding intervals are sufficiently fine.

Initial calculations indicate that full or partial replacement of H2O by CO2 is readily detected by the AVO recording configuration, particularly with the long offset events. Difference seismogram amplitudes of surface-recorded multi-component particle velocities range up to 25%. Also, equivalent elastic medium responses, where elastic parameters are assigned by (low-frequency) Gassmann formulae, prove to be inadequate at higher spectral bandwidths. Finally, these sensitivity modeling experiments are currently being extended to a vertical seismic profiling (VSP) configuration.

Sandia National Laboratories is a multiprogram science and engineering facility operated by Sandia Corporation, a Lockheed-Martin company, for the US Department of Energy's National Nuclear Security Administration, under contract DE-AC04-94AL85000.