Stochastic inversion of seismic and electromagnetic data for CO₂ saturation prediction

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Stochastic inversion of seismic (AVA) and electromagnetic (CSEM) data are used to predict reservoir porosity and CO₂ saturation. The inversion uses Markov Chain Monte Carlo (MCMC) sampling techniques coupled with statistical rock-physics models. The parameters estimated are, V_p/V_s , acoustic impedance, density, porosity, water saturation and a Lithology indicator. Smoothing is achieved by use of a spatial correlation length in a Markov Random Field representation of the Lithology indicator. The algorithm is demonstrated using a detailed 2D synthetic model constructed for benchmarking inversion algorithms that has been adapted to replace hydrocarbon with CO₂ in the reservoir sands. Synthetic seismic and CSEM data are used to test the resolution of porosity and CO₂ saturation predictions under a range of experimental variables. Three types of rock-physics models are considered; 1) linear regressions between variables, 2) Gaussian distribution fits to clusters of variables in two dimensions, and 3) N dimensional multivariate covariance distributions, where N is the total number of inversion parameters. The choice of rock physics model, the proximity of wells used for rock physics, and data noise levels all effect the quality of the porosity and CO₂ saturation prediction. Predictions of porosity and CO₂ saturation are better when the porosity and saturation are included in the inversion (1 step inversion) compared to inverting only for geophysical parameters followed by a stochastic estimation of porosity and CO₂ saturation given the geophysical parameters (2 step inversion).