Uncertainty Analysis of CO₂ Migrations and Chemical Reaction Based on Variations of Rock Permeability and CO₂ Injection Rates

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Abstract

The carbon dioxide capture and storage (CCS) are recognized to be feasible techniques for mitigation of carbon dioxide. The feasibility of storing CO₂ in deep formations has been discussed in the technical literature over the last decade. Due to large capacity and availability of geologic formations for most countries, the geologic storage methods are well developed and many sites are on the stage for possible large-scale operations. This study employs TOUGHREACT-ECO2N model to investigate the structural trapping and solubility trapping processes during the sequestration of carbon dioxide for the case in Changua Coastal (Chang-Bing) Industrial Park. The proposed stochastic approach uses Monte Carlo simulation (MCS) to assess the effect of variations of rock permeabilities and CO₂ injection rates on the migrations of CO₂ plumes. A total of 500 Monte Carlo realizations were simulated for different variances of log permeabilities and CO₂ injection rates. The CO₂ plume extends to about 4km distance from the wellbore after an injection of 100 years. The MCS simulation results show that the variations of permeabilities will lead to significant variations of the CO₂ plumes when the variance of log permeability is greater than 1.0. The simulation results indicated that the variations of permeability would lead higher variations of CO₂ concentration than do the variations of injection rates. Calcite dissolves rather than precipitates in the injection CO₂ plume region because of slightly low pH values near injection points. In the CO₂ plume region, the delayed pH values caused by CO₂ gas dissolution and calcite dissolution, pH values around 5 are maintained as long as both CO₂ gas and calcite mineral are presented. With the extent of simulation time, pH in the plume area gradually increases with time due to mineral precipitates.