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The Impact of Geologic Heterogeneity on CO_2 Injection with Simultaneous Brine Extraction and Economic Uncertainty for Large-Scale CO_2 Sequestration

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Performance assessment of CO_2 sequestration opportunities at the scale of the United States presents challenges for coping with geologic and economic uncertainties. Inaccurate estimation of suitable flow properties could result in drilling wells in parts of a formation that could not physically accommodate the needed injection rates and storage volumes. Data paucity and heterogeneity in geologic properties necessitates probabilistic approaches for estimating CO_2 injection and simultaneous brine extraction rates (for beneficial use such as power-plant cooling or pressure management) and associated costs. We present an Integrated Assessment Model (IAM) that assesses CO_2 injection rates with or without simultaneous brine extraction for the saline reservoirs identified in the National Carbon Sequestration Database (NatCarb). We have linked NatCarb reservoirs to injectivity rock types. We define these rock types quantitatively by probability distribution functions (PDFs) of permeability and porosity, and spatial correlation models. Thus, IAM has flexibility in calculating CO_2 injectivity and brine productivity while coping with heterogeneity, and then determining the uncertainty in well-associated costs. For computational efficiency, IAM performs injectivity and productivity calculations with analytical solutions that have been validated by numerical simulation and comparison to available field data. The solutions incorporate spatially varying properties through PDFs that are based on upscaling of geostatistical realizations of the injectivity rock types. A key method of the geostatistics is linear coregionalization, which defines the linear relationship between porosity and log permeability with a specified correlation coefficient, r, of the regression while maintaining the spatial correlation of each variable. The major finding is high sensitivity of well-associated costs to permeability. Error in field prediction of an order of magnitude in permeability may be the difference between an economically and physically viable or unfeasible site due to potentially order of magnitude change in the number of required injection wells. Finally, we present the affects of varying the correlation between permeability and porosity on injectivity and productivity estimates.

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