XVIII International Conference on Water Resources
CMWR 2010
J. Carrera (Ed)
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Impact Of Geological Heterogeneity On Early-Stage CO_2 Plume Migration

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Injection of CO_2 into saline aquifers involves many complicated processes, including two-phase flow dynamics, inter-phase mass transfer (dissolution), geochemical reactions, and possible non-isothermal effects. In terms of time, the process can be divided in two phases: injection and plume migration over long time scales. The objectives of CO_2 storage studies are defined as to maximize the injection volume/rate and to minimize the risk of leakage.

The problem of CO_2 storage differs from oil recovery prediction not only in the objectives of study, but also in the time scales considered for the process (thousands of years compared to tens of years). In addition, the characteristic length scale of the flow is much larger. Working with long time and spatial scales and huge amounts of uncertainties poses the question of how detailed the geological description should be?

Within oil recovery, the impact of geological uncertainty on the production forecast has been thoroughly investigated, e.g., in the SAIGUP project. That study focused on shallow-marine reservoirs. To study different factors, synthetic realistic models were made and tens of thousands of cases were run for different production scenarios. The results showed big influence of the structural and sedimentological description on the well production responses.

Herein, we use the SAIGUP structural and sedimentological models to study two questions related to CO_2 storage:

- How sensitive is the injection and early-stage migration to uncertainty and variability in the geological description?
- What simplifying assumptions are allowed in averaging the geological attributes over scales?

Heterogeneity classes are defined based on different depositional sedimentology and levels of shale or clay barriers. We assume two-phase flow with slight compressibility for the supercrtitical CO_2. The injection scenarios are defined based on the typical objectives as discussed above, considering the operational constraints on wells.