Geological CO2 storage is a key technology to be utilized for preventing the industrial

CO2 emission into the atmosphere. A successful storage operation requires safe ge-

ological structures with large storage capacity. The practicality of the technology is

challenged by various operational concerns from site selection to monitoring the in-

jected CO2 in the long-term.

The research in this report is aimed to address the significance of a sophisticated

geological modeling that can help in prediction of the storage performance. In the

first part, we investigate the significance of assessing the geological uncertainty and

its consequences in the site selection and early stages of the storage operations. This

includes the injection period and the early migration time of the injected CO2 plume.

The key part of the research is the extensive set of realistic geological realizations

used in the analysis. The heterogeneity is modeled by the most influential geological

parameters in a shallow-marine system. Among those parameters are the aggradation

angle, levels of barriers in the system, faults, lobosity, and progradation direction.

A typical injection scenario is simulated over 162 realizations and major flow re-

sponses are defined to measure the success of the early stages of CO2 storage opera-

tions. These responses include the volume of trapped CO2 by capillarity, dynamics of

the plume in the medium, pressure responses, and risk of leakage through a failure in

the sealing cap-rock. Impact of geological uncertainty on these responses is investi-

gated by comparing all cases for their performance. The results show a large variations

in the responses due to changing the geological parameters. Among the main influen-

tial parameters are the aggradation angle, the progradation direction, and the faults in

the medium.

A sophisticated geological uncertainty study requires large number of detailed sim-

ulations that are time consuming and computationally costly. The second part of the re-

search introduces a work-flow that employs an approximating response surface method,

which is called arbitrary polynomial chaos (aPC). The aPC is fast and sophisticated

enough to be used practically in the process of sensitivity analysis and uncertainty and

risk assessment. We demonstrate the work-flow by combining the aPC with a global

sensitivity analysis technique, namely the Sobol indices, which is a variance based

method and has proven to be practical for complicated physical problems. Probabilis-

tic uncertainty analysis is performed by applying the Monte-Carlo process using the

aPC. The results show that the aPc can be used successfully in an extensive geological

uncertainty study.