Geological storage of CO_2: Heterogeneity impact on pressure behavior

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Abstract

Due to the high rates of industrial CO_2 emission, it is an operational objective to maximize CO_2 injection rates into underground geological formations. Forcing high volumetric rates into the injection wells can result in an over-pressurized system, which can cause possible breaches in the formation integrity and can increase the risk of CO_2 leakage.

The goal of this study is to investigate and control the pressure buildup during injection to avoid the uncontrolled development of fractures in the medium. Herein, we study how geological heterogeneity influences the pressure behavior of a typical CO_2 injection operation. Five geological feature variables are considered as inputs for the sensitivity analysis. These features include various degrees of faults, lobosity, flow barriers, aggradation angle, and progradation direction.

Two injection scenarios are examined. In the first scenario, CO_2 is injected through a single well at a constant rate and the pressure in the well and the domain is allowed to build up without limit. In the second scenario, a pressure constraint is set on the well and the target injection rate is reduced to keep the pressure below the safety limit. Model responses related to pressure buildup and propagation within the system are defined and demonstrated using a single geological realization. Results for all realizations are presented and discussed accordingly. We conclude by ranking aggradation angle, progradation direction, and faults as the most influential geological parameters.

The novelty of this work lies in the use of a large parametrized ensemble of equiprobable and realistic geological realizations to analyze how pressure builds up and propagates through the storage medium. The demonstrated workflow is generic and can be used in any extensive pressure study. Likewise, our investigation reveals several generic patterns in how the different geological parameters influence the pressure buildup in this type of shallow-marine systems, but the relative ranking of which parameters are the most important may, of course, change if one selects a different injection scenario, injection location, number of injector, or set of geological realizations.