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 breakings in the formation integrity and can increase the risk of CO_2 leakage.

The goal of this study is to investigate the injection pressure considerations that are needed 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 levels 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 injection rate is changed to keep the pressure below the limit. Model responses related to pressure build-up and propagation within the system are defined and demonstrated using a selected case. Results for all cases 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 is in the extensive geological realizations and the introduced methods to analyze the pressure within the medium. The demonstrated work flow can be used in any extensive pressure study. The rankings of geological parameters based on their influence may change by selecting a larger model size or different injection scenarios, injection locations, or number of injectors.

1 Introduction

The industrial CO_2 emission rate is expected to increase over the next decade if necessary preventive actions are not taken. For example, according to the Energy Information Administration, carbon dioxide emissions in the United States are forecast to reach 6.41 billion