Abstract

Due to the high rates of industrial CO_2 emission, it is an operational obejectiv to maximize CO_2 injection rate into underground geological formations. Forcing the injection wells with high volumetric rates can result in an overpressurized system with possible breakings in the formation integrity, which increases the risk of CO_2 leakage.

The goal of this study is to investigate the injection pressure considerations that are needed to avoid uncontroled development of fractures in the medium. Herein, we study how the geological heterogeneity influences the pressure behavior of a typical CO_2 injection operation. Five variable geological features are considered as input for sensitivity analysis. These features span a realistic geological space.

Two injection scenarios are examined. In the first scenario, CO_2 is injected at a constant rate and the pressure in the well and the domain is allowed to build up unlimitedly. 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 for a selected case. Results for all cases are presented and discussed accordingly. We conclude by ranking the most influential geological parameters.

1 Introduction

The increasing level of green-house gases in the atmosphere, and in particular carbon dioxide, is believed to cause global climate changes. The industrial emission rate is expected to increase over the next decade, without taking necessary preventive actions. For example, according to the Energy Information Administration (EIA), the US carbon dioxide emissions are forecast to reach 6.41 billion tonnes by 2030. The Kyoto protocol proposed an emission cut which requires 1.75 billion tonnes of annual carbon dioxide reduction [10].

Geological storage of CO_2 is a proposed solution to fight global climate change. Clear operational criteria and policies must be made for the process to avert unwanted consequences. Concerns connected to putting a large mass of CO_2 into underground geological formations are not limited to the spatial distribution of the injected fluid. The pressure signals imposed through the injection point can travel beyond the scale of the CO_2 invaded zones. Although geological barriers can hinder the pressure exchange between different regions, pressure can transfer through low-permeable rocks where the CO_2 is trapped by capillarity.

In addition to the depleted oil and gas fields, deep geological aquifers are practical targets for geological storage of CO_2. If injecting into brine aquifers, the pressure waves can push brine into connected fresh water aquifers and contaminate them. Brine displacement issues are discussed in [4] by defining open, closed, and semi-closed aquifer boundaries. Brine might also leak through abandoned wells into other zones. Cailly et al. [3] discuss well design considerations to prevent any leakage through wells.

Geomechanical deformations are important during injection period. They can lead to changes in effective permeability and porosity. It is possible that the pressure build-up around injection wells will crack the rock with uncontrolled fracture extensions to the structural sealing layers. Faults can be activated due to high pressure in the system, providing a