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Review

Geomechanical challenges during geological CO_2 storage: A review

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ABSTRACT

Carbon capture and sequestration (CCS) method is the only viable method for reducing massive amount of carbon dioxide (CO_2) from the atmosphere to prevent the subsequent environmental and health threats. However, the process is accompanied with geomechanical risks due to the unavoidable pore pressure buildup, such as caprock failure, reactivation of existing faults, poroelastic response of rock and well integrity loss. Not only may the risks lead to undesirable environmental concerns such as CO_2 leakage to the surface, induced seismicity, and surface uplift, but it also would disturb achieving the public's consensus on the CCS process. In this paper, we present an overview of possible geomechanical risks during CCS. We also review the mechanisms and theories of possible geomechanical risks during the CCS and the relevant precedent studies are introduced and described. This study would facilitate understanding the potential geomechanical risks during the CCS and establishing the optimal design of the CCS process to achieve the public acceptance. Some challenges related to handling the geomechanical risks during the CCS are also discussed.

1. Introduction

According to the Paris agreement, 197 countries have reached for the 'low greenhouse gas emissions development' [1], which restricts the greenhouse gas emission of the signees to achieve the global average temperature rise within 1.5 °C above pre-industrial levels. The anthropogenic CO_2 emission will be reduced by the carbon capture, utilization and storage (CCUS) technologies. When the carbon capture and sequestration (CCS), also known as the geological carbon storage (GCS), is adopted, CO_2 is injected and stored in a targeted geologic structure such as depleted hydrocarbon reservoirs, saline aquifers, and underground caverns [2,3]. CCS is the most feasible way to remove and sequestrate the massive amount of CO_2.

According to the sustainable development scenario projected by International Energy Agency (IEA), at least 650 megatons of the anthropogenic CO_2 is required to be stored annually by 2030 to meet the emission goals. The CO_2 storage capacity of the current large commercial CCS projects is approximately 40 megatons per year, which is only 6 % of the desired amount [4]. In the same manner, the South Korea government plans to reduce the CO_2 emission by 40 % business as usual (BAU) in 2030 and achieve the net-zero by 2050. The amount of CO_2 sequestrated by the CCS process is expected as at least 55 megatons, 69 % of the total CO_2 reduction until 2050 [5]. One of the target geologic structure is the depleted Donghae gas reservoir in East Sea, which is planned to be repurposed for the CO_2 storage, where 0.4 megaton of CO_2 per year are expected to be geologically stored from 2025 [6].

When CO_2 is injected and stored into an underground geological structure, the pore pressure buildup is unavoidable. The change of the pore pressure redistributes the stress status and induces the poroelastic responses at the caprock and target formation [7–10]. If severe, it may lead to geomechanical hazards such as leakage of the injected CO_2, surface uplift, and induced seismicity, which are major environmental concerns during the CCS project. In addition, the well integrity should be considered because the injected CO_2 could be leaked through any component of the well what was designed to be used as the flowing path. Uncontrolled release of injected fluid can shorten life cycle of the well and it may lead to CO_2 leakage. Therefore, establishment of the optimal CCS design considering the geomechanical risks is important to perform the environmentally safe project and to achieve the public acceptance [11].

There are geomechanical risks during a CCS process, but investigations of causes, mechanisms and post-analysis methods have not yet been conducted [12]. In this paper, geomechanical risks potentially caused by the pore pressure buildup due to the CO_2 injection will be

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