221 (2023) 211404

Contents lists available at ScienceDirect

Geoenergy Science and Engineering

journal homepage: www.sciencedirect.com/journal/geoenergy-science-and-engineering

Formation uplift analysis during geological CO_2-Storage using the Gaussian pressure transient method: Krechba (Algeria) validation and South Korean case studies

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ARTICLE INFO

Keywords:
Carbon storage
Uplift
Gaussian pressure transient
Krechba gas field
Pohang basin
Donghae gas reservoir

ABSTRACT

The Paris Climate Agreement of 2015, along with the commitments in the South Korean *2050 Carbon-Neutral* Scenario, highlights the importance of carbon capture and storage (CCS) to counter advancing global warming. During CCS, carbon-dioxide enriched fluid is injected into a geological formation, which causes pore pressure increases. The CCS must occur safe and stable, which requires geomechanical modeling to analyze the effects of formation uplift and subsidence. In this study, surface uplift and subsidence were predicted with a recently developed Gaussian pressure transient (GPT) method, in advance of the anticipated CO_2-injection schemes to ensure a secure storage process. The GPT-results were first validated against field observations obtained from the In Salah CCS-site (Algeria). Next, the GPT-method was applied to two potential CCS target locations in South Korea: (1) the Pohang basin, and (2) the Donghae gas reservoir. Maximum uplifts of 25.42 and 32.55 mm, respectively, were estimated for each location. In addition, the effect of installing a relief well to mitigate the uplift was studied. Subsidence was estimated around the relief well due to production. The presence of the relief well aided the mitigation of both uplift and subsidence. Our study shows that preliminary analysis of uplift and subsidence of potential CCS-sites is possible with the GPT-method. In addition, it was shown that installing (one or more) relief well(s) for the purpose of mitigating the severe uplift caused by injection is feasible.

1. Introduction

According to the *2050 Carbon-Neutral* Scenario (Kim et al., 2022) set by the collaborative committees of the South Korean government in 2021, at least 55.1 to 84.6 million tonnes of CO_2-equivalent have to be either stored underground by carbon capture and storage (CCS) or utilized with carbon capture utilization and storage (CCUS) technology by 2050. CCS and CCUS are perceived as the two most viable technologies of sequestrating the CO_2 into underground formations, which contribute to diminishing the greenhouse gas proportion in the atmosphere to mitigate global warming. Therefore, the global efforts to meet the Paris Climate Agreement are led by both public and private sectors. In order to achieve the desired injection and storage schedule set by the South Korean government in support of the Paris Agreement, assessing the secure injection of CO_2 into underground formations is as crucial as meeting the required storage capacity targets.

To ensure the secure injection of CO_2, detailed studies must precede the successful sequestration and permanent storage of the injected fluid. Such studies critically require a geomechanical analysis of the stress regime changes, fracture mechanism, and discontinuity integrity (Kresse and Weng, 2018; Wu and Olson, 2015; Cao and Sharma, 2022a, 2022b). During CO_2-injection into a geological structure, geomechanical response will occur due to the unavoidable pore pressure buildup. If not managed properly, the pressure may exceed a critical limit leading to brittle failure, which may lead to potential leakage of injection fluid (Roberts et al., 2018), accompanied by caprock deflection (Li et al., 2015), fault reactivation (Cappa and Rutqvist, 2011), unintended hydraulic fracturing (Appriou, 2019), unexpected seismic activity (Nicol et al., 2011; Zoback and Gorelick, 2012), and formation deformation (Teatini et al., 2011).

The formation deformation initially may seem less severe to the general public because it accumulates slowly over a certain period with

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https://doi.org/10.1016/j.geoen.2022.211404
Received 7 June 2022; Received in revised form 8 December 2022; Accepted 26 December 2022
Available online 29 December 2022