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ORIGINAL ARTICLE

# Seal integrity and feasibility of $CO_2$ sequestration in the Teapot Dome EOR pilot: geomechanical site characterization

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**Abstract** This paper reports a preliminary investigation of $CO_2$ sequestration and seal integrity at Teapot Dome oil field, Wyoming, USA, with the objective of predicting the potential risk of $CO_2$ leakage along reservoir-bounding faults. $CO_2$ injection into reservoirs creates anomalously high pore pressure at the top of the reservoir that could potentially hydraulically fracture the caprock or trigger slip on reservoir-bounding faults. The Tensleep Formation, a Pennsylvanian age eolian sandstone is evaluated as the target horizon for a pilot $CO_2$ EOR-carbon storage experiment, in a three-way closure trap against a bounding fault, termed the S1 fault. A preliminary geomechanical model of the Tensleep Formation has been developed to evaluate the potential for $CO_2$ injection inducing slip on the S1 fault and thus threatening seal integrity. Uncertainties in the stress tensor and fault geometry have been incorporated into the analysis using Monte Carlo simulation. The authors find that even the most pessimistic risk scenario would require $\sim$10 MPa of excess pressure to cause the S1 fault to reactivate and provide a potential leakage pathway. This would correspond to a $CO_2$ column height of $\sim$1,500 m, whereas the structural closure of the Tensleep Formation in the pilot injection area does not exceed 100 m. It is therefore apparent that $CO_2$ injection is not likely to compromise the S1 fault stability. Better constraint of the least principal stress is needed to establish a more reliable estimate of the maximum reservoir pressure required to hydrofracture the caprock.

**Keywords** $CO_2$ · Geomechanics · Natural leakage · Fault stability · Seal integrity

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## Introduction

One of the main issues to be addressed for $CO_2$ sequestration to be a viable carbon management solution is the risk of $CO_2$ leakage. From a technical perspective, depleted or mature oil and gas reservoirs hold great promise as sequestration sites due to the fact that hydrocarbons were held in them for geological periods of time, implying the presence of effective trap and seal mechanisms. However, it has long been known (e.g., Raleigh et al. 1976) that fluid injection causes changes in the pore pressure and stress field that could potentially alter the initial seal of the reservoir by either hydraulically fracturing the cap rock or by triggering slip on pre-existing faults by reducing the effective normal stress on the fault plane (see review by Grasso 1992).

In light of this, one of the key steps in the evaluation of any potential site being considered for geologic carbon sequestration is the ability to predict whether the increased pressures associated with $CO_2$ sequestration are likely to affect seal capacity. Although it has been recognized that one possible leakage route in depleted oil and gas fields may be the damaged casings of old or abandoned wells, the focus of the present work is to evaluate the potential risk of $CO_2$ leakage through natural pathways by inducing slip on faults that are currently sealing and bounding the hydrocarbon reservoirs.