Assessment of CO2 leakage using mechanistic modelling approach for CO2 injection in deep saline aquifer of Lithuanian basin in presence of fault and fractures

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Introduction

- In the context of carbon capture and storage (CCS), which involves capturing CO_2 emissions from power plants and industrial facilities and storing them underground, leakages can result from improper storage site selection, poor monitoring, or human error during injection or storage operations.
- The injection of CO_2 into deep saline aquifers offers significant potential for large-scale and long-term storage of carbon dioxide.
- The consequences of CO_2 leakage are far-reaching and encompass environmental, economic, and public health impacts.

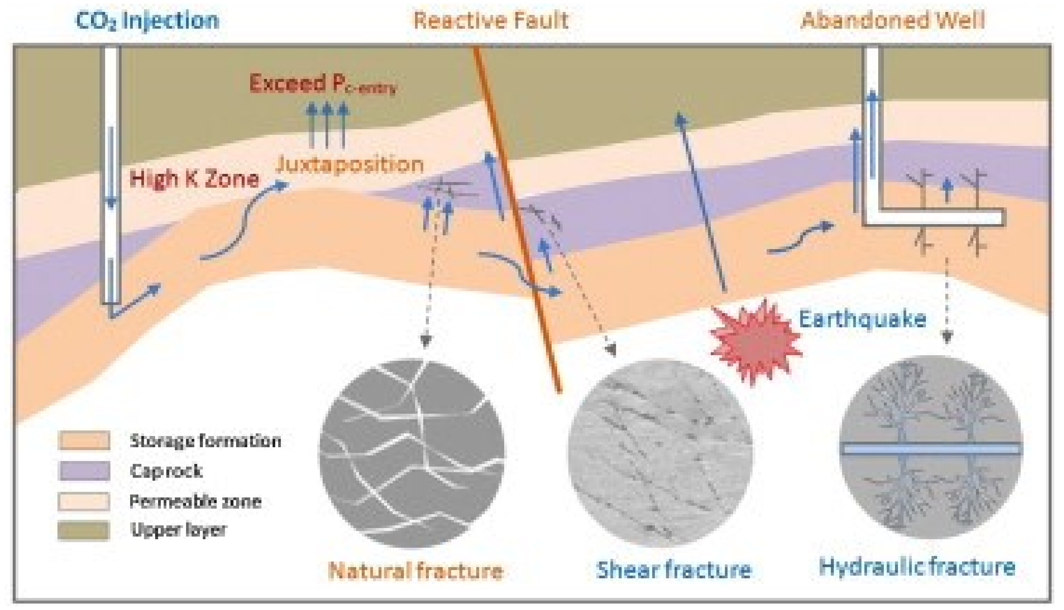


Figure 1. Leakage pathway

- Environmental consequences include the acidification of water bodies, deterioration of soil quality, and negative effects on vegetation and biodiversity. The release of large quantities of CO_2 into the atmosphere can exacerbate climate change, contributing to global warming and further disrupting delicate ecosystems.
- Economically, CO_2 leakage can lead to substantial financial losses.

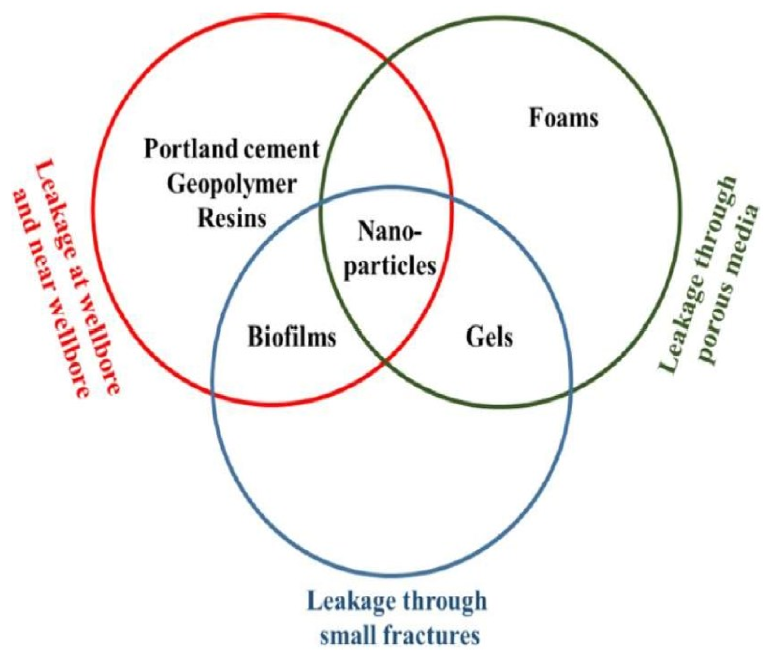


Figure 2. Sealant for CO_2 Leakage for different type of Leakage

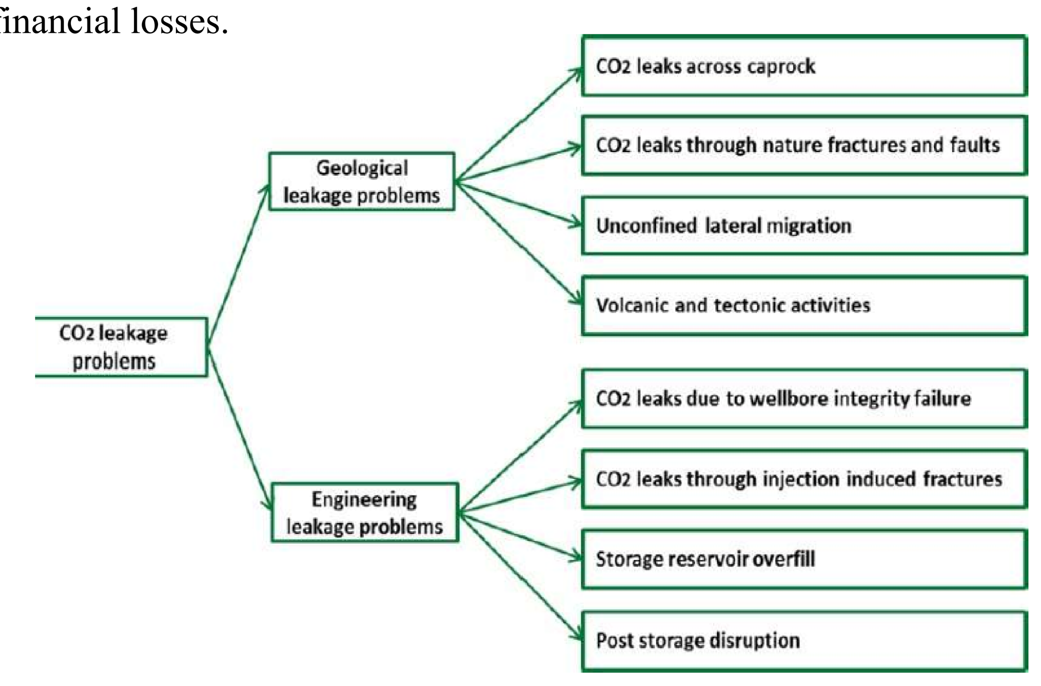


Figure 3. CO_2 Leakage Classification

Objectives

- To investigates the impact of fracture permeability on CO_2 leakage volumes in the context of CO_2 injection into Syderiai deep saline aquifer for carbon capture and storage (CCS) applications.
- The study examines how the leakage volume may evolve over time in Syderiai deep saline aquifer.

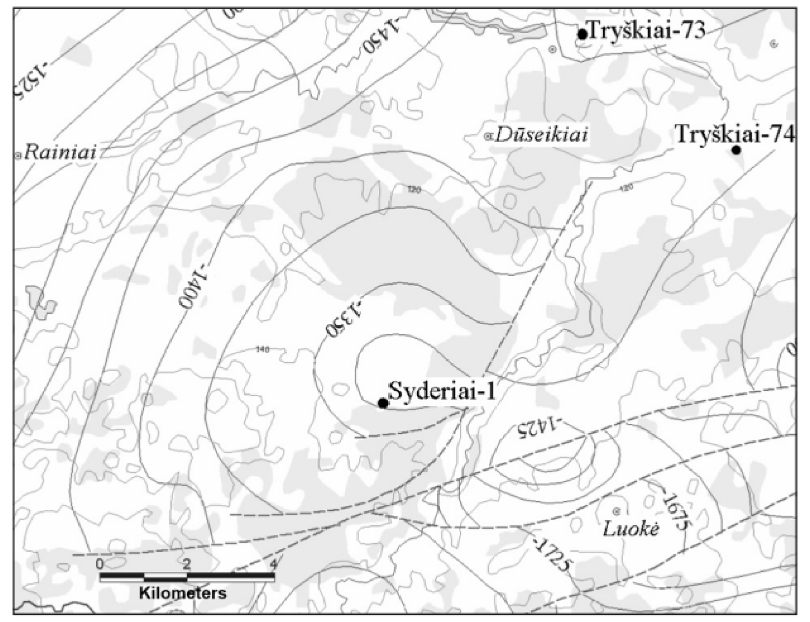


Figure 4. Geographical location of Syderiai field

Methodology

- In this study, we present a comprehensive methodology, based on simulation, for estimating the total leakage volume of CO_2 from deep saline aquifers of Lithuanian basin, considering the presence of both dissolved and free-phase CO_2.
- The methodology utilizes mechanistic models to quantify the amount of dissolved CO_2 in water above and below the cap rock, providing valuable insights into the extent of CO_2 dissolution and its variation in different zones of the aquifer.

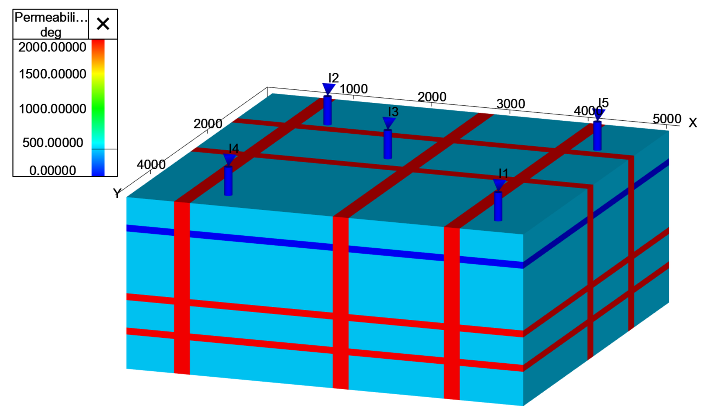


Figure 5. Permeability distribution Grid block for 2000 md Fracture

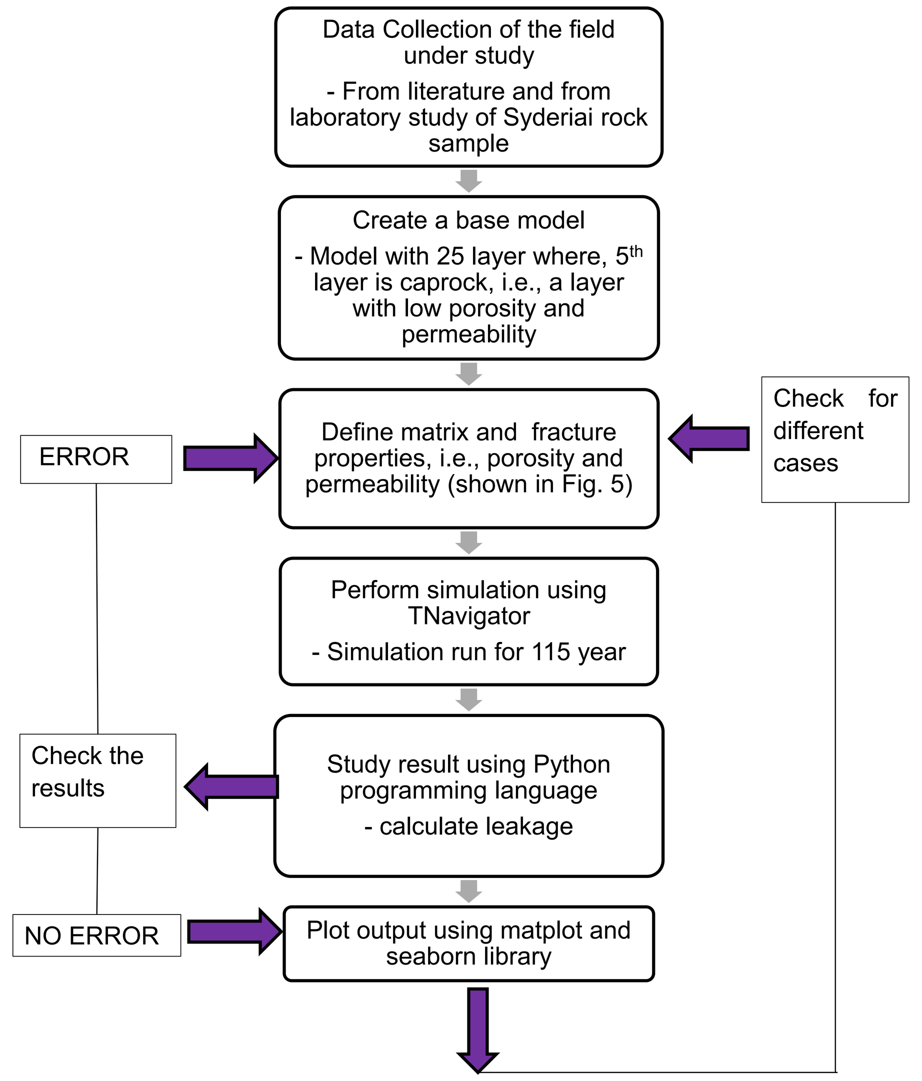


Figure 6. Flowchart of the adopted methodology.

Results

Effect of Variable Permeability

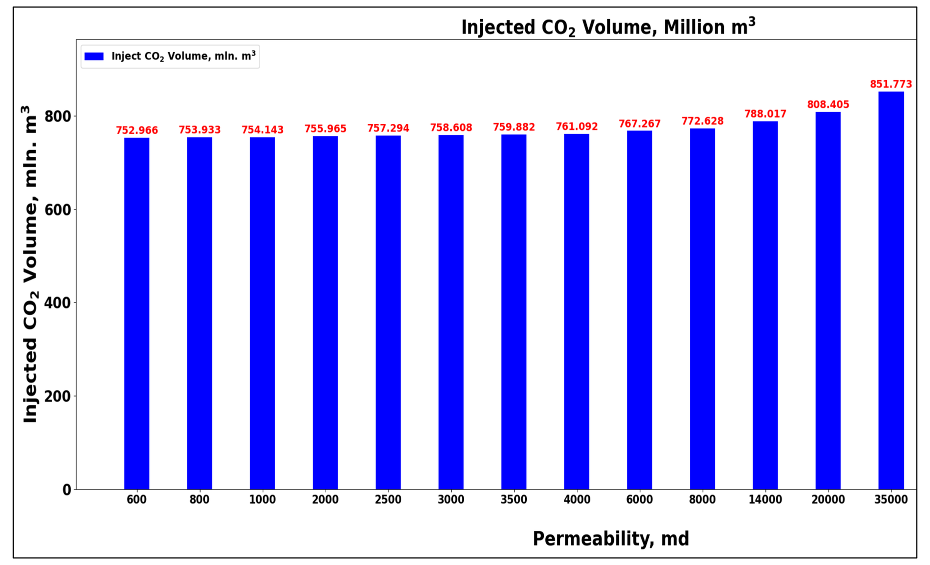


Figure 7. Effect of Variable permeability on injected volume of CO_2

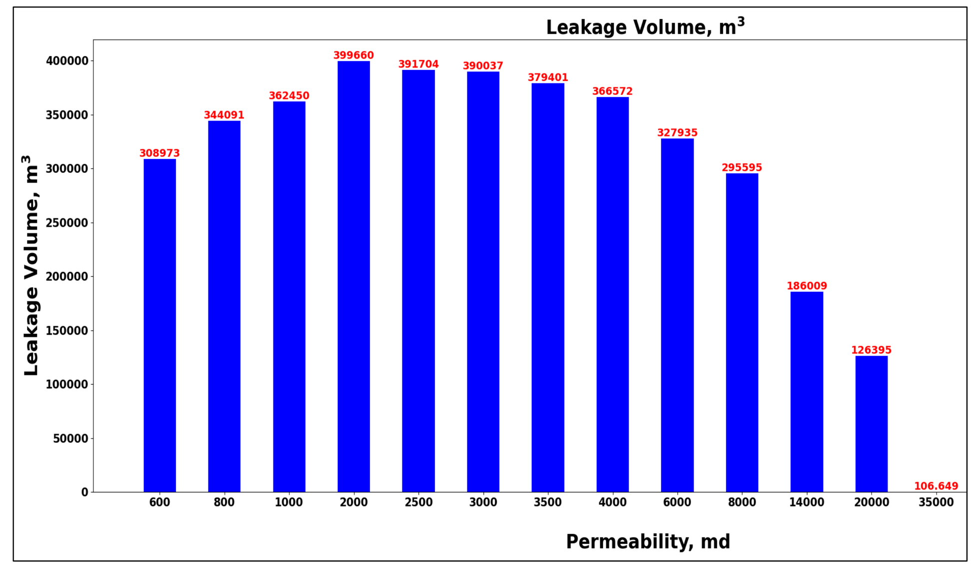
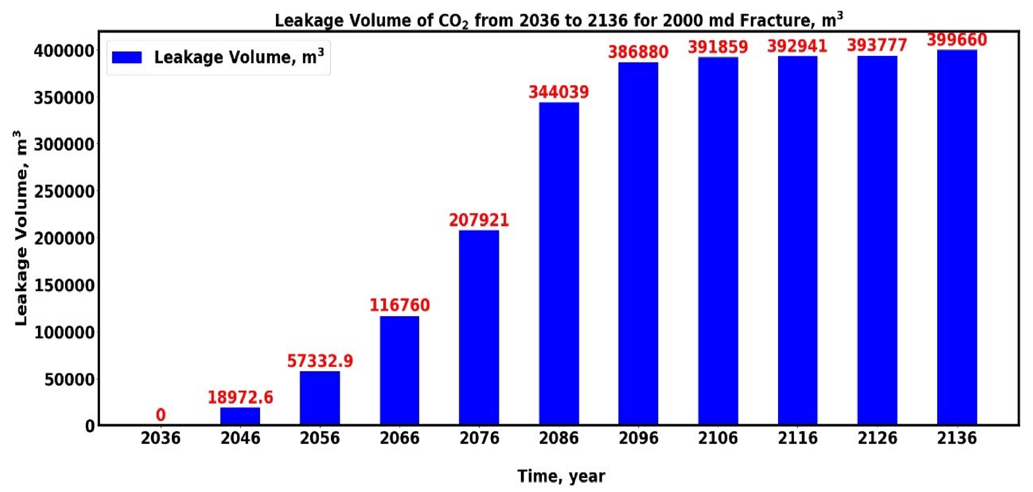
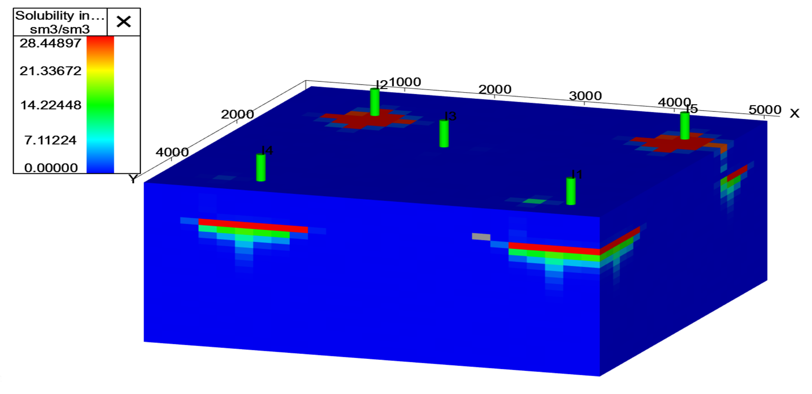


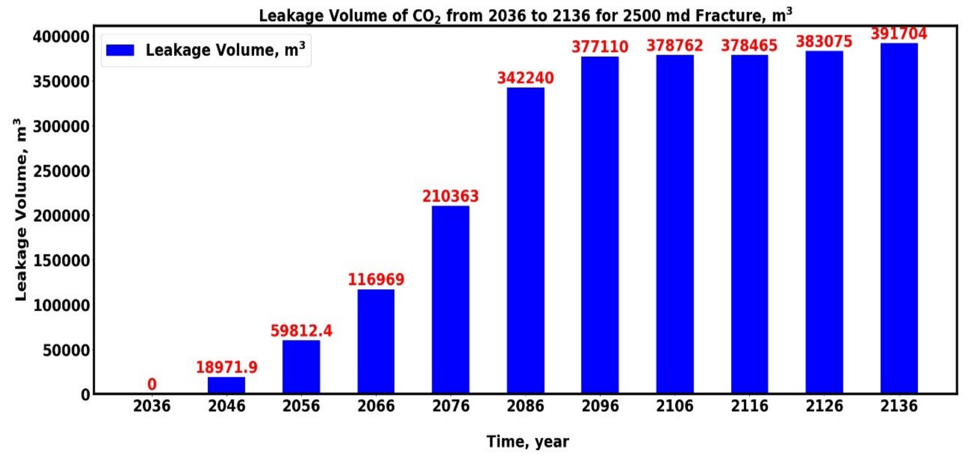
Figure 8. Effect of Variable permeability on leakage volume of CO_2

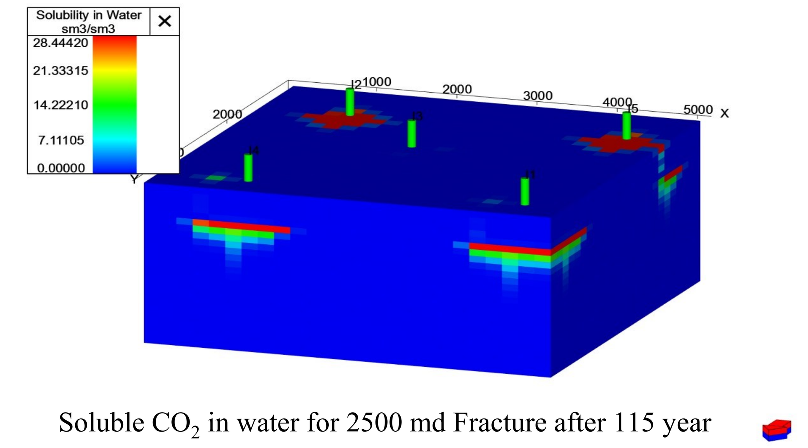
Changes in Leakage volume with time



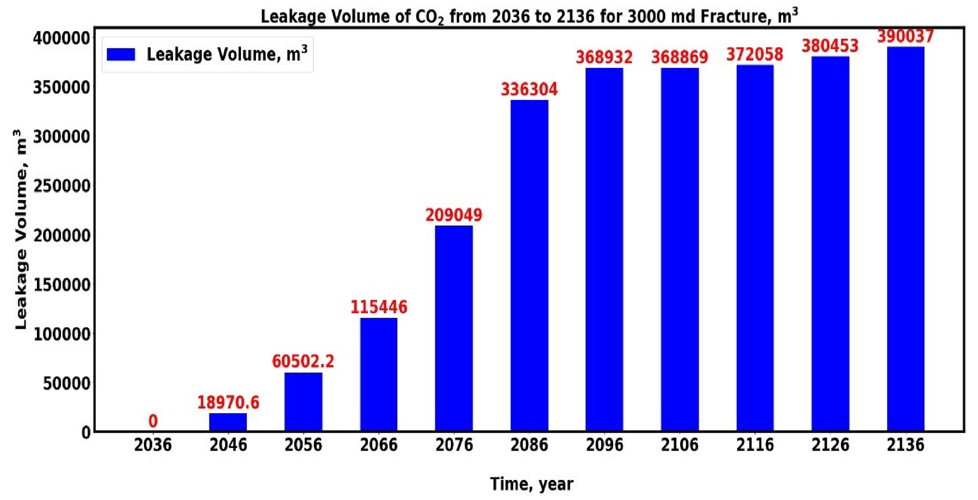


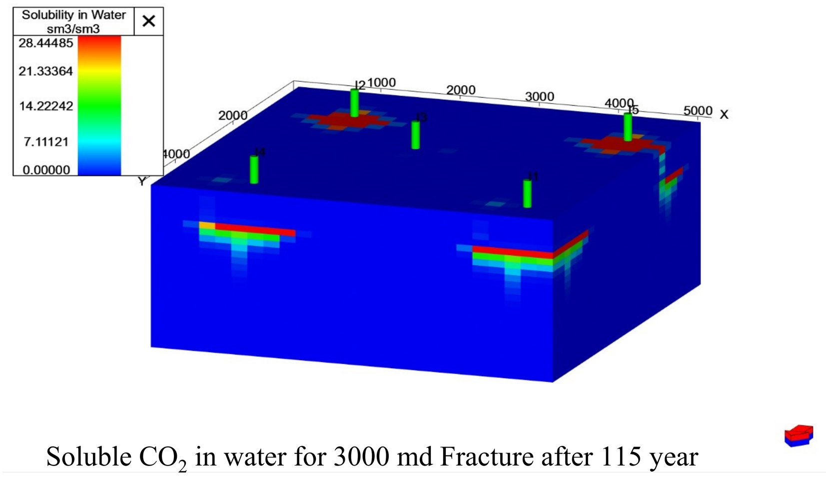
Soluble CO_2 in water for 2000 md Fracture after 115 year





Soluble CO_2 in water for 2500 md Fracture after 115 year





Soluble CO_2 in water for 3000 md Fracture after 115 year

Conclusions

- This work tests the leakage volumes using different fracture permeability values From 2022 to 2136.
- Optimal conditions for minimizing leakage were identified. Investigations were made for the temporal dynamics of CO_2 leakage volumes.
- As fracture permeability increases till 2000 md, free leakage volume of CO_2 increase. From 2500 md, free leakage volume is CO_2 decrease.
- When fracture permeability is increased, it provides a more efficient pathway for CO_2 flow. This enhanced flow can initially lead to an increase in the leakage volume of CO_2.
- However, as CO_2 migrates and pressurizes the reservoir, it can induce a sealing effect, countering the initial increase. Additionally, higher permeability can enhance capillary forces, immobilizing CO_2 within rock pores, and further decreasing leakage volume.
- Analysis was carried out to look at factors such as cap rock degradation through geochemical reactions and pressure differentials, to understand how the leakage volume evolved over time.
- For study leakage volume with time, from 2022 to 2036, no leakage is observed for 2000 md permeability cases. During the initial years up to 2046, there is a relatively uniform leakage volume. However, in the subsequent 30 years, we observe higher leakage volumes.

Acknowledgements

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