AMINAHO, E.N., SANAEE, R. and FAISAL, N. 2022. *Evaluation of caprock integrity for underground storage of CO2 in depleted oil and gas reservoirs using machine learning approaches*. Presented at the Applicability of hydrocarbon subsurface workflows to CCS conference, 28-29 April 2022, London, UK.

Evaluation of caprock integrity for underground storage of CO2 in depleted oil and gas reservoirs using machine learning approaches.

AMINAHO, E.N., SANAEE, R. and FAISAL, N.

2022

EVALUATION OF CAPROCK INTEGRITY FOR UNDERGROUND STORAGE OF CO_2 IN DEPLETED OIL AND GAS RESERVOIRS USING MACHINE LEARNING APPROACH

ROBERT GORDON UNIVERSITY ABERDEEN

Student Name: Efenwengbe Nicholas Aminaho **Student Number:** 1600684 **Email:** e.aminaho@rgu.ac.uk

Principal Supervisor: Dr Reza Sanaee **Co-Supervisor:** Professor Nadimul Faisal

Background to the Study

CO_2 geosequestration represents one of the most promising options for reducing atmospheric emissions of CO_2. Caprock integrity ascertained based on the petrophysical and geomechanical properties of caprock is vital to ensure safe and sustainable storage of CO_2 (Liu et al., 2020).

Shale and carbonate rocks are typical caprock for CO_2 geological storage, but their failure behaviour have not been fully understood due to their severe heterogeneity and anisotropy (Liu et al., 2020). So, it is vital to apply machine learning techniques in understanding caprock behaviour under several conditions.

So far, no study has focused on caprock integrity, using machine learning approach to select best depleted petroleum reservoirs for CO_2 storage using caprock mechanical and petrophysical properties. Therefore, the aim of this research is to evaluate caprock integrity under cyclic stress loadings based on variation in pressure and CO_2 injection temperature.

Problem Statement

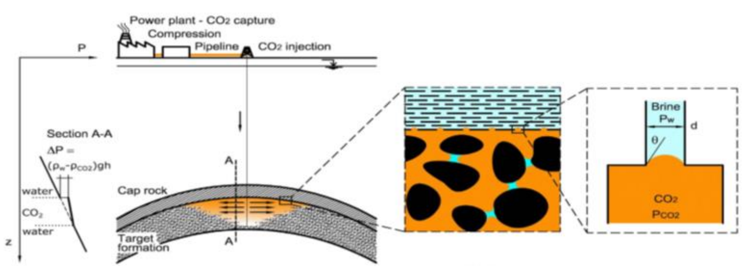

Figure 1: Capillary pressure effect in caprock integrity (Source: Espinoza and Santamarina, 2017)

Research Methodology

The research design is based on numerical simulations and machine learning. Machine learning techniques (traditional decision tree and random forest models) were adopted to evaluate effect of pressure variation on caprock integrity. The results are validated with experiments performed by other scholars.

The numerical simulation is based on the experimental results and the idea that upstream pressure develops from CO_2 injection, and water pressure acting in the opposite direction to counterbalance the effect of CO_2 injection pressure.

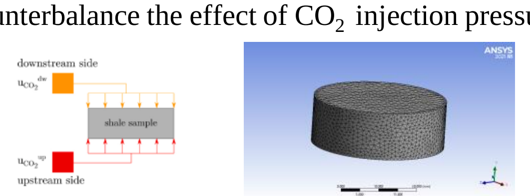

Figure 2: Caprock sample and how pressures act

Experimental Data

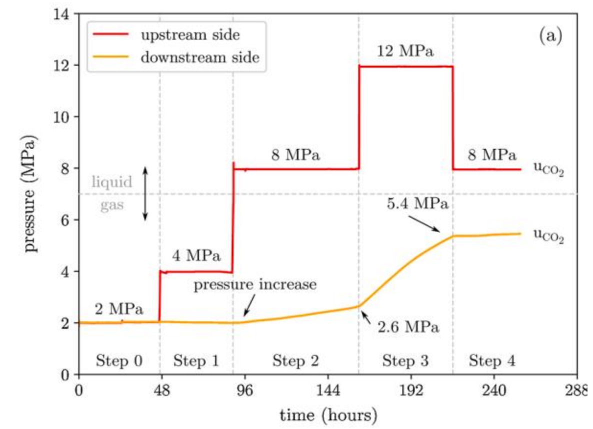

Figure 3: Data from capillary pressure experiment (Source: Minardi et al., 2021)

Numerical Simulation

The numerical simulation is based on coupled thermal and structural simulation on ANSYS Workbench using results from the experiment.

Results

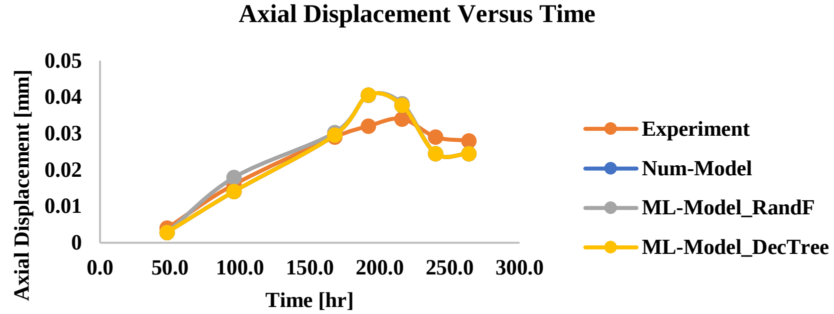

Figure 4: Effect of pressure variation in caprock on axial displacement during CO_2 injection.

Max Rel Error of 0.2953 (MAPE= 15.6%; MdMRE=12.6%) in Exp & simulation

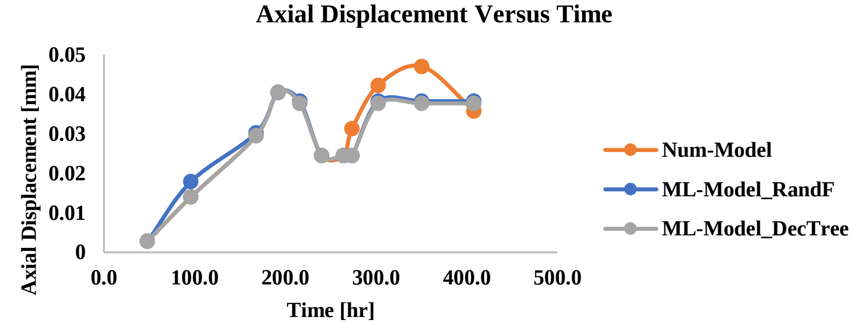

Figure 5: Effect of pressure variation in caprock on axial displacement during CO_2 injection over extended numerical simulation.
MAPE= 13.2%; MdMRE=10.8% DTM || MAPE= 12.9%; MdMRE=9.6% in RFM

Further Results

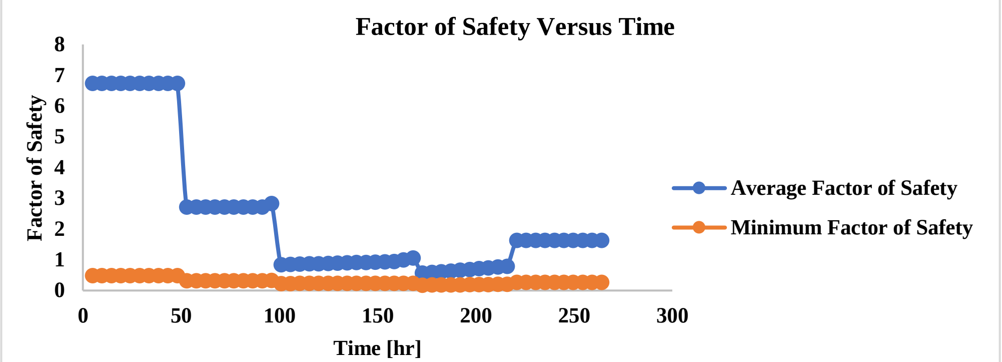

Figure 6: Factor of safety of the period of CO_2 injection

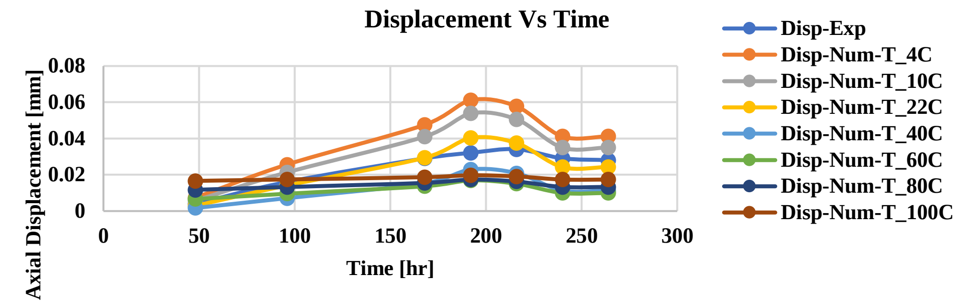

Figure 7: Effect of CO_2 injection temperature variation on axial displacement.

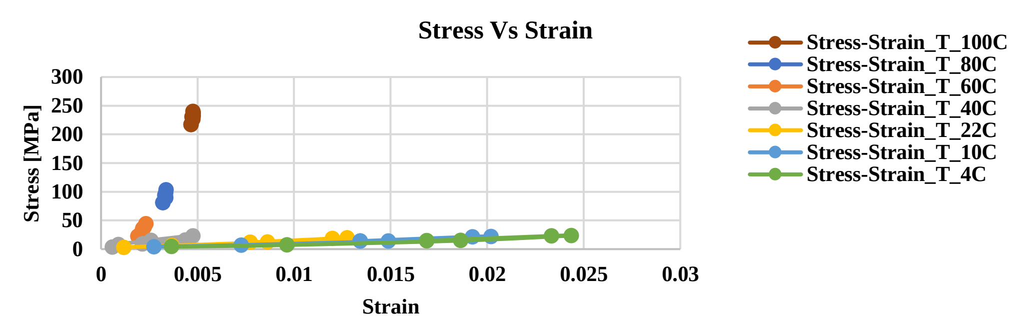

Figure 8: Stress-Strain relationship under varying CO_2 injection temperature
Stress concentration (barrier) develops as temperature increases.

Appreciation

The author is grateful to The Robert Gordon University for providing tuition funding for this research.

References

Espinoza, D. N. and Santamarina, J. C. (2017). "CO_2 breakthrough—Caprock sealing efficiency and integrity for carbon geological storage", *International Journal of Greenhouse Gas Control*, 66, pp. 218-229.

Liu, Y. et al. (2020) Investigation on mechanical behaviors of shale cap rock for geological energy storage by linking macroscopic to mesoscopic failures. *Journal of Energy Storage*, 29, pp. 1-15.

Minardi, A. et al. (2021) "Experimental assessment of the hydro-mechanical behaviour of a shale caprock during CO_2 injection". *International Journal of Greenhouse Gas Control*, 106, pp. 1-15.