geoconvention
Calgary • Canada • May 15-17 2023

Critical Geomechanical Parameters in CCS Projects: Essential Experimental Measurements

Arian Velayati[1], Brent Nassichuk[2], Cory Twemlow[3]

[1] Geomechanics Specialist, Advanced Rock Properties Division, AGAT Laboratories Calgary, Alberta, Canada

[2] Director of Rock Properties, Advanced Rock Properties Division, AGAT Laboratories, Calgary, Alberta, Canada

[3] Operation Manager, Advanced Rock Properties Division, AGAT Laboratories, Calgary, Alberta, Canada

Summary

The International Energy Agency (IEA) analysis of major technology challenges considers carbon capture and storage (CCS) one of the critical technologies for reaching net zero targets. IEA 2°C scenario (2DS) requires CCS to deliver 94 Gt of CO2 emission reductions by 2050. According to Global CCS Institute's 2021 report, there are more than 27 active large-scale commercial CCS projects around the world; or more than 50 projects if small/pilot projects are included in the stats. These sites inject approximately 20 Mt CO2/year, much lower than the injection target of 1 Gt scCO2 by 2030. Currently, most injections are performed in sandstone reservoirs and saline aquifers, where the reservoir has excellent petrophysical properties for storage (volumetric storage capacity, porosity, permeability, etc.). For instance, the Cambrian Basal Sandstone Unit, which is the target CO2 storage interval in the Quest and Aquistore sequestration projects, is a large aquifer with good petrophysical attributes resulting in potential storage of about 3Gt of CO2. As a result of CO2 injection, various geomechanical, thermal, hydrological, and geochemical parameters undergo complex and interrelated transformations and changes. In recent years, there have been controversies over the success of such projects from a geomechanical perspective. Zoback et al. (2012) questioned the potential of large-scale geologic storage projects in accomplishing their goals, claiming that large injection volumes could trigger faults and induce earthquakes which in turn threaten the seal integrity of geological structures. Through modeling and experimental studies, several researchers have pushed back and showed that the faults are not likely to become activate during CO2 injection operations (Vilarrasa and Carrera, 2015; Vilarrasa et al., 2016). Although promising results in projects such as Shell's Quest have been observed in recent years, it appears that it is still too soon to tell if the project has been or will be successful. Pressure build-up with time, transfer of pressure to other layers such as the basement, creep, and other geochemical transformations that take place in the long term change the state of strain and rock properties and determine the long-term performance of CCS projects. This study discusses the short and long-term geomechanical threats to CCS projects through the review of previous projects design and the related data. Additionally, this presentation addresses the critical geomechanical parameters that need to be measured and monitored during the CCS projects, the types of testing that provide the required dataset for geomechanical models, customized testing that should be introduced for CCS applications, the formations from which cores should be collected for testing purposes, and the timing of sample collection for testing are discussed in the context of CCS operations.

Observations

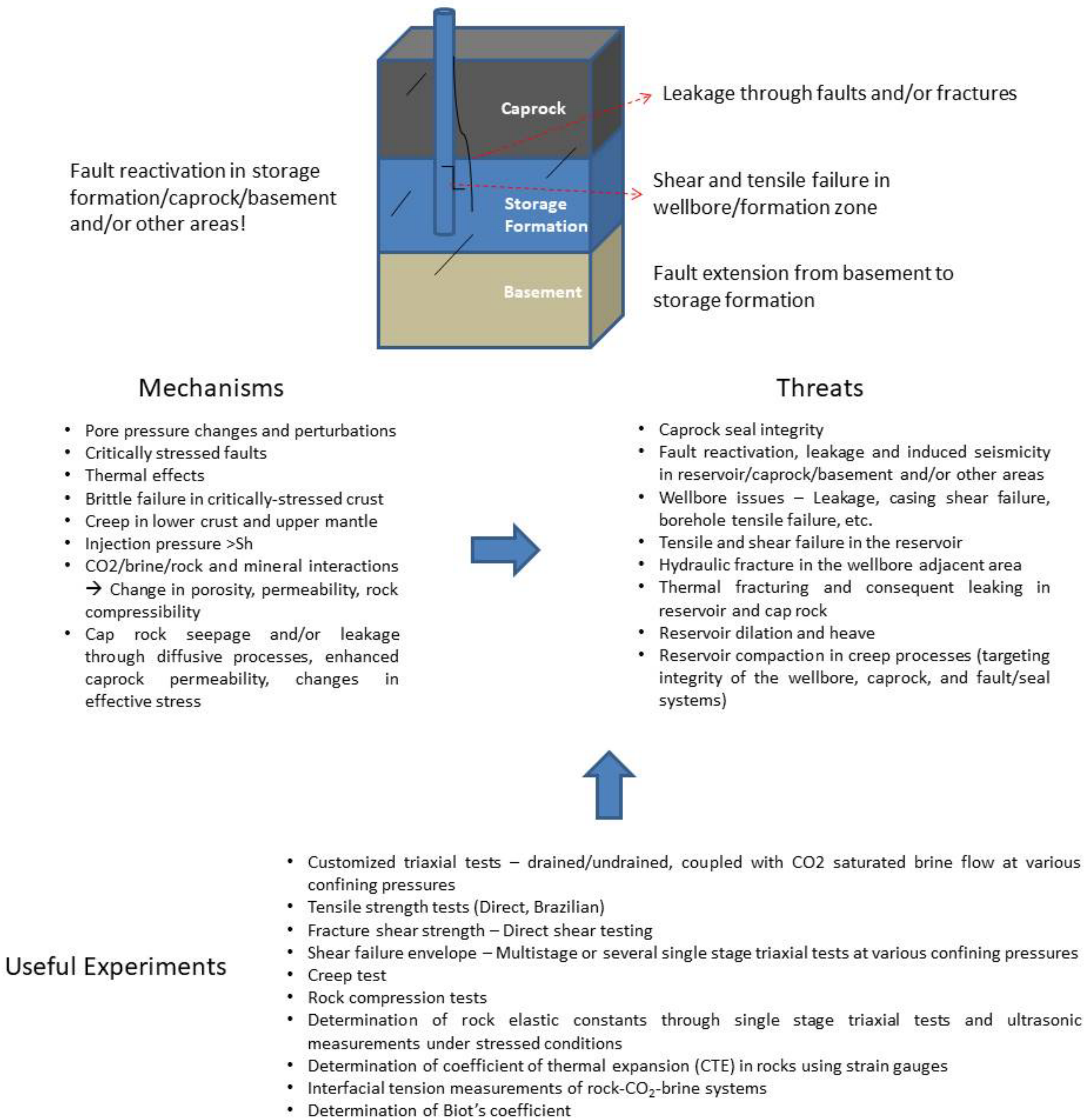

Figure 1- Overview of geomechanical threats in CCS operations and the responsible mechanisms

References

Cotton, A., Gray, L. and Maas, W., 2017. Learnings from the Shell Peterhead CCS Project front end engineering design. Energy Procedia, 114, pp.5663-5670.

IEA (2016), 20 years of carbon capture and storage, IEA, Paris https://www.iea.org/reports/20-years-of-carbon-capture-and-storage, License: CC BY 4.0

Pachauri, R.K. and Meyer, L.A., 2014. Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change.

Vilarrasa, V. and Carrera, J., 2015. Geologic carbon storage is unlikely to trigger large earthquakes and reactivate faults through which CO2 could leak. Proceedings of the National Academy of Sciences, 112(19), pp.5938-5943.

Vilarrasa, V., Makhnenko, R. and Gheibi, S., 2016. Geomechanical analysis of the influence of CO2 injection location on fault stability. Journal of Rock Mechanics and Geotechnical Engineering, 8(6), pp.805-818.

Zoback, M.D. and Gorelick, S.M., 2012. Earthquake triggering and large-scale geologic storage of carbon dioxide. Proceedings of the National Academy of Sciences, 109(26), pp.10164-10168.