Introduction

The geological storage of CO_2 may cause considerable changes in underground conditions with respect to temperature. These changes are more profound around the injectors intersecting the storage layers, but still significant in the entire storage zone. Depleted hydrocarbon reservoirs and saline aquifers qualifies were identified as potential candidates for CCS storage projects. Severe temperature changes downhole and cooling of the formations during various stages of injections can cause increased risk of cap-rock integrity breach.

Method and/or Theory

Based on wellbore-scale temperature modelling, a range of temperature difference close to the injection wellbore were assumed for the analysis. Using this temperature changes, the possible range of stress reduction induced by the thermal expansion/contraction of the rocks in the reservoir storage and caprock layers were calculated from the thermoelastic equations. The estimation considers the elastic properties of rocks, linear expansion coefficient of storage and caprock as derived from core tests and the difference between reservoir and bottom hole temperature.

Results

Assuming the cap rock will experience the same level of cooling effect as the reservoir, the reservoir and caprock fracture pressure incorporating the thermal stress effect at the well location at the start of the injection stage/end of history matching and end of prediction were estimated. The predicted temperatures were modelled from well modelling for the start of injection and end of prediction stage. At the start of the injection stage, the results shows that the reservoir fracture pressure with thermal stress effect reduced to 1040 psi for the shallowest storage layer and to 1470psi for the deepest storage layer at the location of the injection wells. The caprock fracture pressure incorporating the thermal stress effect at the well location reduced to 1450 psi for the shallowest storage layer and to 2600 psi for the deepest storage layer. Similarly, the stress reductions for the end of the prediction stage were estimated for the reservoir and caprock layers. In addition, similar exercise was carried out for the saline aquifers to understand the impact of thermal stress on caprock integrity.

Conclusion

Based on the analysis, it was found that the storage layer pressures did not exceed the fracture pressure values of the caprock considering the thermal stress effects. The 5% uncertainty associated to the S_{hmin} modelling (carried over from the 1D geomechanical modelling) are also considered and it was found that the integrity of the caprock is still maintained. This study helped in providing a firsthand information on caprock integrity risks based on 3D static geomechanical even before moving to 4D dynamic simulation modeling.

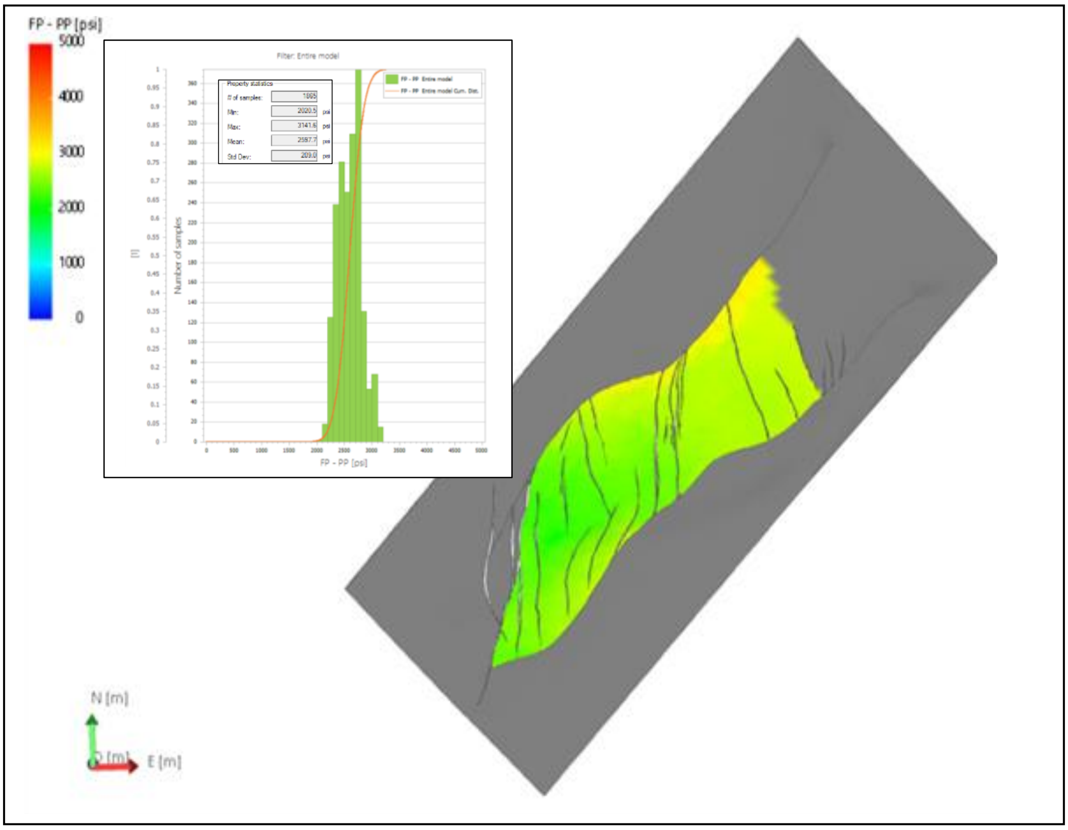

Figure 1 *Map of Difference of Fracture Pressure and Initial Reservoir Pressure Distribution in the main storage layer and its statistical distribution. The reservoir area for the respective storage layers is delineated and the reservoir pressures are mapped onto it. The fracture pressures for the caprock immediately above the storage layers are mapped. The difference between reservoir and fracture pressure controls how much additional pressure can be injected into the storage layer before the caprock integrity is compromised. In this case the mean of threshold pressure is approximately ~2600 psi for the main storage layer.*

	Reservoir Sandstone Properties		Caprock Shale Properties			Reservoir Sandstone Properties	Caprock Shale Properties
Depth (m)	Fracture Pressure at Initial Pressure (psi)	Fracture Pressure at Start of Inj (psi)	Fracture Pressure (psi)	Reservoir Temp (deg. C)	Bottom Hole Temp (deg C)	Fracture Pressure with Thermal Effect – Start of Inj (psi)	Fracture Pressure with Thermal Effect (psi)
XXX	1700	1430	1789	69.44	-9.32	1036.9	1452.2
XXX	2463	1973	2593	80.94	-7.68	1153.2	1831.9
XXX	2650	2034	2789	84.81	-7.13	1131.2	1945.3
XXXX	2768	2116	2914	85.56	-7.02	1184.2	2023.7
XXXX	2788	2128	2935	86.59	-6.88	1125.3	2048.4
XXXX	3191	2352	3359	91.83	-6.13	1141.4	2321.4
XXXX	3259	2419	3431	92.42	-6.04	1242.0	2316.7
XXXX	3474	2581	3657	95.62	-5.59	1228.9	2453.9
XXXX	3908	2803	4114	101.06	-4.81	1133.3	2430.3
XXXX	4181	2925	4401	104.82	-4.28	1196.7	2641.3
XXXX	4221	3138	4443	112.22	-3.22	1165.9	2355.2
XXXX	5004	4029	5267	112.22	-3.22	2057.0	3179.2
XXXX	4798	3559	5050	112.22	8.84	1466.7	2598.9

Table 1 *Table 7 summarizes the reservoir and caprock fracture pressure incorporating the thermal stress effect at the well location at the end of prediction stage.*

References

1. Chatterjee, A., Younessi, A. (2024). Geomechanical Risk Investigation of Geological Sequestration of CO2 In Depleted Reservoirs, Proceedings, Indonesian Petroleum Association (IPA)

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