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Caprock Integrity and Induced Seismicity Considerations for CCS and Geothermal Applications

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Summary

Ensuring containment of injected fluid is essential for all injection operations. The past few years have seen a dramatic increase in the number of CCS and Geothermal projects being initiated. Although there are important differences between CCS projects and most geothermal projects in terms of caprock and induced seismicity risks, these projects are similar in that the reservoir and wellbore often undergo significant thermally induced stress changes during injection. These projects have also all been required to evaluate the potential for loss of wellbore or caprock integrity during injection and many have also been required to address the potential for induced seismicity. The degree of rigor in these evaluations has varied widely from region to region and has depended on the geological setting, the applicable regulatory requirements and the availability of relevant data. In this presentation we will show some of the learnings from the past few years that are most relevant to the Canadian context. An overview will be given of the regulatory requirements specific to evaluating the risk of loss of containment during injection. Specific project examples will be discussed together with general best practices. These best practices have been developed during the many decades that industry has dealt with containment issues during waterflooding, water disposal, acid gas injection and other related projects.

Theory / Method / Workflow

It is useful to approach the issue of caprock integrity with a simple conceptual understanding of the dominant factors impacting caprock integrity before moving to more complex models. The relative impact of pore pressure change due to fluid injection versus the impact of temperature change in the reservoir due to cold injection can be understood by considering the elastic inclusion theory described by Segall and Fitzgerald (1996). Using a similar approach, we compare CO2 sequestration projects and geothermal projects from several different geological settings to demonstrate the influence of in situ stress, reservoir temperature change, and the thermo-mechanical properties of the rocks on the severity of caprock integrity risks during injection. We then compare the results of these simple models to results obtained through 3D coupled geomechanical models to demonstrate some instances where evaluating caprock integrity risk requires a more involved approach.

Results, Observations, Conclusions

Simple models provide some useful insight into the factors driving both caprock integrity and induced seismicity during cold fluid injection. They allow us to quickly understand the approximate magnitude of thermally induced stress changes that can be expected during injection. With this understanding we can therefore assess the general risks of loss of caprock integrity or of induced seismicity. 3D coupled geomechanical modeling results for several recent North American projects demonstrate how this approach is useful for constraining the spatial extent of more complex issues such as subsidence above the injection zone, the potential for shear failure in the

caprock above the injection zone, the potential for inadvertently fracturing the reservoir and the spatial extent of increased potential of induced seismicity.

Novel/Additive Information

Attendees should leave the presentation with a general understanding of which parameters are likely to be most relevant to their project areas and how to address the uncertainty in evaluating both caprock integrity and induced seismicity potential using either simple models or more detailed numerical models.

Acknowledgements

References

Segall, P., and Fitzgerald, S.D. A note in induced stress changes in hydrocarbon and geothermal reservoirs. Tectonophysics 289, p. 117-128.