



## Effects of Rock Mechanical Properties and Deformational Behavior on Caprock Integrity in Thermal Operations

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### Summary

As a critical input in determining the maximum steam injection pressure, caprock integrity assessment in thermal operations has become increasingly important because of the potential severe consequences of caprock integrity breach on environment, safety and project economics. This paper aims to evaluate the effects of rock mechanical properties, rock constitutive and deformational behavior on caprock integrity in thermal stimulation of heavy oil/bitumen reservoirs through coupled geomechanical and fluid flow simulations.

### Method

Thermal recovery processes such as steam injection can significantly alter pore pressures and in-situ stresses, not only in the reservoir, but also in the surrounding caprock. Because of the complex thermo-poro-mechanical coupling that prevails during thermal stimulation processes, in this study we use a numerical simulation workflow that integrates finite difference fluid flow and finite element geomechanical simulators. Various rock elastic and strength properties, constitutive models, drained/undrained rock behavior are simulated to illustrate the effects of each parameter on caprock integrity.

### Results, Observations, Conclusions

Simulation results show that even though the permeability in the caprock is extremely low, temperature in the caprock increases as the reservoir rock is heated. Heat conduction plays a major role in heating up the caprock. Because of the low permeability in the caprock, pore pressure increases with the temperature. Pore pressure increases even further under mechanical loading because of the undrained behavior of the caprock. The pore pressure increase in the caprock alters the stress state and makes the caprock more prone to failure. In addition, the rock deformation and stress change in the reservoir due to steam injection also changes the stresses in the caprock. Rock elastic properties affect the magnitude of the pore pressure and stress changes, rock strength properties determine the condition at which the caprock yields and the selected constitutive model determines the post-yield rock deformation. The results show that it is essential to perform coupled simulations for understanding caprock integrity, ensure the accuracy of the input parameters and the appropriate model is selected for such simulations.

### Novel/Additive Information

This paper attempts to quantify the impact of various parameters on caprock integrity through coupled simulations. It presents a novel workflow to simulate undrained rock behavior in coupled fluid flow and geomechanical simulations. In selecting the appropriate constitutive models, the paper uses a new approach to simulate the behavior of the rock under laboratory testing conditions using a finite element model and compare the simulated stress-strain relation with that obtained from laboratory testing.