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Non-linearity And Stress-dependency In Unconsolidated Formations and the Associated Impacts on Thermal Recovery

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Summary

In thermal recovery from unconsolidated oilsands reservoirs and in association with fluid mobility, formation compressibility and modulus of elasticity are among the most important controlling factors in pressure transient and stress redistribution behavior, which collectively affect the steam chamber development. The variability in bulk compressibility and also modulus of elasticity of rock in unconsolidated formations has been captured through the development of elegant constitutive models and has been readily integrated into coupled reservoir-geomechanical simulation packages. In order to assess the significance of these variabilities and as a complement to the previous works in this area, this work presents an analytical assessment of the impacts on the redistribution of stress (stress-paths) and the onset of geomechanical mobilization (shear dilation) under the assumption of uniaxial deformation. Within the scope of this paper, a series of (semi-) analytical modeling is conducted where special attention has been devoted to (1) the vast range of depths of the existing oilsands reservoirs and the associated implications on the stress distribution and redistribution, (2) the impacts on the onset of geomechanical mobilization, and (3) the evaluation of geomechanical mobilization potential of thermal versus cold pressurization. The results show that (1) the potential impact of stress dependency on the range of variability of the rock material properties (modulus of elasticity, Poisson's ratio and formation compressibility) is more significant for shallow reservoirs as compared to mid-depth and deep reservoirs, (2) the injection pressure required for the onset of geomechanical mobilization can be underestimated if the non-linearity in the mechanical properties are overlooked, and (3) the thermal geomechanical mobilization has a considerably higher potential within practical ranges of operating pressures as compared to non-thermal techniques. The inherent limitations of the analytical workflows as well as a discussion on the supporting efforts through coupled reservoir-geomechanical simulations are also presented.