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Wellbore stability analysis in carbonate reservoir considering anisotropic behaviour

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Carbonate reservoirs represent a major part of the world oil and gas reserves. In particular, recent discoveries in the pre-salt offshore Brazil place big challenges to exploration and production under high temperatures and pressures (HTHP). During production, the extraction of hydrocarbons reduces pore pressure and thus causes an increase in the effective stress and mechanical compaction in the reservoir. The compactive deformation and failure may be spatially extensive or localized to the vicinity of the wellbore, but in either case the consequences can be economically severe involving surface subsidence, well failure and various production problems. The analysis of wellbore stability and more generally of deformation and failure in carbonate environments hinges upon a relevant constitutive modeling of carbonate rocks over a wide range of porosities, in particular, observed microstructure of samples suggests anisotropic behaviour.
In this study, we performed a wellbore stability analysis for a lateral wellbore junction in three dimensions. The complex geometry for the wellbore junction was modeled with tetrahedral finite elements considering a rate independent elastic-plastic isotropic material that presented linear behavior during elastic strain and associated flow rule. A finite element model simulating drilling and production phases were done for field conditions from a deep water reservoir in Campos basin, offshore Brazil. In this context, several scenarios were studied considering true 3D orientation for both in situ stresses and geometry of the wellbore junction itself.
We discussed the impact of constitutive modeling, considering anisotropic ductile damage and pressure sensitiveness on the wellbore stability. Parameter values for the analysis were based based on experimental data on two micritic porous carbonates. Series of conventional triaxial experiments were performed at room temperature in dry and wet conditions on samples of Comiso and Tavel limestones of respective porosity 17 and 16%. The wet samples were deformed in drained conditions with 10 MPa pore pressure. The initial yield stresses were identified as the critical stresses at the onset of shear-enhanced compaction, subsequent yield stresses were considered to depend on hardening given by the plastic volumetric strain. For both limestones, we found that water had a moderate effect on the yield stresses but influenced significantly the hardening behavior of the rocks.