Geophysical Research Abstracts, Vol. 9, 02067, 2007
SRef-ID: 1607-7962/gra/EGU2007-A-02067

The impact of constitutive modeling of porous carbonate rocks on wellbore stability analysis

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Carbonate reservoirs represent a major part of the world oil and gas reserves. 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 cases 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 this study, we compiled recent experimental data on the dilatant and compactant failure of seven limestones with porosities ranging from 10% to 38%. These data were obtained from conventional triaxial experiments performed at room temperature and constant strain rate in dry and wet conditions. 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. We applied several constitutive models, such as the Drucker-Prager, the Mohr-Coulomb and the cap models, to the experimental data. A two dimensional wellbore stability analysis was performed. The wellbore was modeled as a long cavity surrounded by a rate independent elastic-plastic isotropic material that presented linear behavior during elastic strain and associated flow rule. Plane strain finite element simulations of drilling and production phase were done using a mesh of 4000 triangular elements and field conditions from a deep water reservoir in Campos basin, offshore Brazil. The impact of constitutive modeling and rock porosity on the wellbore stability

will be discussed.