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International Geomechanical Analogues

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ABSTRACT

Faults and fractures that are created by geological processes, as well as man-man fractures created by hydraulic stimulation, have a major impact on reservoir fluid flow during production. Geomechanical techniques provide answers to questions on the generation of faults and fractures during geological processes, the dependence of the in-situ stress field on the presence of faults and fractures, the growth of hydraulically stimulated fractures, and the interaction of the stress field with fluid flow processes.

In my presentation, I will present examples showing how geomechanical principles have been applied to understand:

- Development of faults using a workflow of structural restoration and geomechanical forward modelling. The deformation and inelastic strain computed during geomechanical forward modelling can be related to fracture intensity and direction.

- Local variations of stress directions and magnitude around faults and their impact on wellbore stability. Wellbore breakouts are caused by large differential stresses in the wellbore wall, and the azimuth of the breakout is given by the minimum principal stress direction. Breakout observations in wellbore images can therefore be used as calibration data for geomechanical models.

- The potential for fault re-activation during reservoir production, and the associated risk of wellbore failure. Reservoir pressure increase by injection, pressure decrease by production, and temperature changes cause changes in the stress state of the reservoir and surrounding rock. The change in stress state can be resolved to change in normal and shear stress on a fracture plane. If the shear stress on the fault plane exceeds the strength of the fault-plane, slip along the fault plane occurs, and a well penetrating the fault is at risk of shear failure.

- The impact of variations of mechanical properties and stress-field across a field to understand hydraulic fracture growth. Presented examples include identification of regions of high and low fracture propagation pressure for hydraulic stimulation, identification of regions of containment of hydraulic fractures, and the interaction of field production with the pattern of hydraulically generated fractures.

- Change in fracture and fault hydraulic permeability during reservoir depletion, providing explanations for observed early water breakthrough. As the normal and shear stress on fault and fracture plains changes, average fracture aperture can both increase or decrease, thereby changing the hydraulic permeability. This effect is known to have caused early water-breakthrough and decrease in reservoir productivity.

To address all the above questions, stress field computations using a 3D finite element simulator are used, using geophysical measurements for model building and wellbore observations, as well as drilling experience for model calibration.