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Borehole breakouts in transversely isotropic formations and their use as an indicator of in-situ principal stress orientation

H. Lee and I. Song
Korea Institute of Geoscience and Mineral Resources, Daejeon, Korea (isong@kigam.re.kr)

We have developed a semi-analytical model for the stability analysis of a wellbore drilled into transversely isotropic rock formations with preferentially oriented intrinsic weakness planes. The model was then examined in order to evaluate the potential use of borehole breakouts developed in vertical wellbores drilled into such formations as an indicator of in-situ principal stress orientation.
In the model was incorporated strength anisotropy due to the presence of the weakness planes. It was assumed that the weakness planes exist ubiquitously in the formation fully saturated with fluid. For the computation of stress disturbance around the borehole due to drilling, the formation was assumed to be elastically isotropic. Furthermore, the fluxes, which may cause additional stress disturbance, driven by the difference of chemical potential, solute concentration, temperature, and pressure gradient between drilling mud and formation fluid were not taken into account in the calculation of stress disturbance around the borehole.
Our breakout analysis involved multiple transformations of stress components between defined reference coordinate systems, their projection onto the weakness planes, and checking the state stress around the borehole for failure. Two shear failure modes were used to check for failure: shear failure across rock matrix and slippage along the weakness planes. A number of breakout analyses were carried out with varying the orientation of weakness planes relative to the orientation of in-situ stresses for given stress magnitudes and material properties.
Our results show that breakout orientation and width at the borehole wall are strongly dependent on the relative orientation between the weakness planes and in-situ principal stresses. Breakouts are formed either at two diametrically opposite zones or at four locations around the borehole depending on their relative orientations. In addition they are aligned with or rotated from the known direction of minimum horizontal principal stress. Our results suggest that the use of breakouts as an indicator of in-situ stress orientation demands in advance the knowledge of strength parameters of the drilled formations from core tests, of breakout orientation and width from image logs, and of other in-situ stresses, and then wellbore failure analysis using the model.