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Utility of sonic anisotropic measurements in accurate rock mechanics calculation for hydro-fracturing design and wellbore stability analysis in unconventional reservoirs

Objectives/Scope: In recent times, the unconventional reservoirs have emerged as major hydrocarbon prospects and optimum yield from these reservoirs is dependent on two key aspects, viz. well trajectory and hydrofracturing (HF). Simulations for HF operations to estimate the fracture height and width are primarily dependent on rock mechanical properties such as UCS, Young's Modulus and Poisson's Ratio which result from the Geomechanical analysis. Now, the rock mechanical properties are computed from the Sonic measurements which are influenced in the presence of anisotropic shales as a function of well trajectory deviation. In one of the fields under review, the sonic compressional slowness varied by 8us/ft-20us/ft. at the target TVD in shale layer with increase in well deviation and as such, affecting the values of UCS, Young's Modulus and Poisson's Ratio and resulting in misleading fracture height and width while HF simulations. The sonic measurements should be corrected for the anisotropy effect before being used as inputs for geomech. analysis & further simulations. Current paper reviews few case studies where the effects of anisotropy can be envisaged and the Geomechanical workflow used to negate the anisotropy influence on data to help carry out successful HF operations to place frac. stages at optimum depth interval and to minimize breakouts while drilling.

Methods, Procedures, Process: 3D sonic anisotropic processing was carried out to estimate vertical and horizontal Young's Modulus and Poisson's Ratio to be used for stress calculation in shale layer. To negate the effect of anisotropy on Sonic logs across the shale layer in deviated wells, they were corrected using the Thomson parameters derived by considering varying deviation well paths through the same layer. To further constrain the horizontal tectonic strain for accuracy, radial profiles of the three shear moduli obtained from the Stoneley and cross-dipole sonic logs were used at depth intervals where stress induced anisotropy can be observed on sonic waves in permeable sandstone layer. A rock mechanics model was prepared by history matching borehole failures, drilling events and hydro-frac results in vertical and horizontal wells using modified rock properties and more accurate stress profile.

Results, Observations, Conclusions: Geomechanical model with corrected sonic data helped to explain the breakouts in shale layer at 60deg-85deg whereas the original sonic data suggested faster and more competent formation with slight variation in stress profile among shale-sand. Considering shale shear failure, the mud weight used for maintaining maintain good hole conditions at 80deg had to be 0.6ppg-0.8ppg higher than that being used in offset vertical wells. Estimated closure pressure and breakdown pressure showed good match with frac results in deviated wells using new workflow where stress profile was originally not showing much contrast between reservoir and barriers. There was change of 0.03psi/ft-0.07psi/ft. in shale layers using this new workflow which helped to explain frac height and containment.

Novel/Additive Information: This methodology provides more reliable rock mechanics characterization to be used for engineering applications. Study helped to safely and successfully deliver more wells in the area with lesser drilling issues and optimized frac stages.

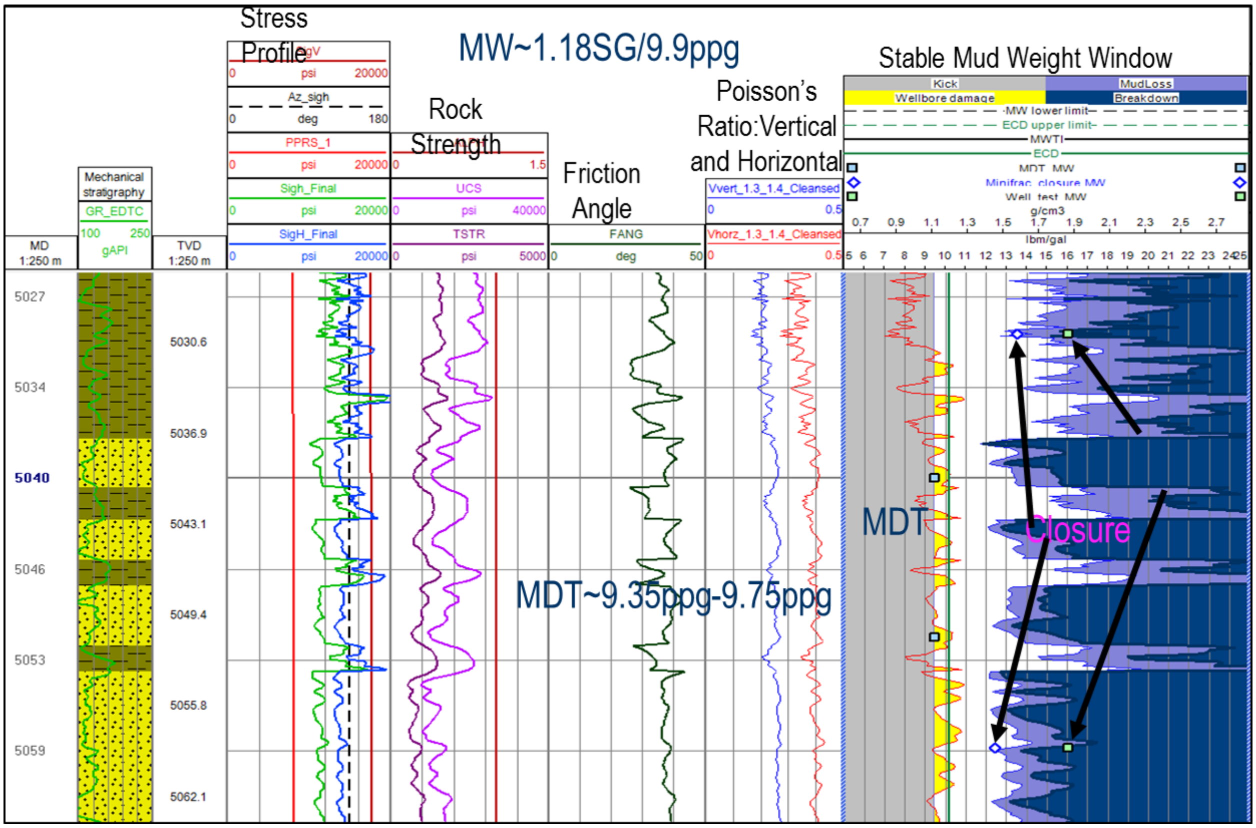

Figure 1: History match of estimated closure and breakdown pressure with hydro-frac job

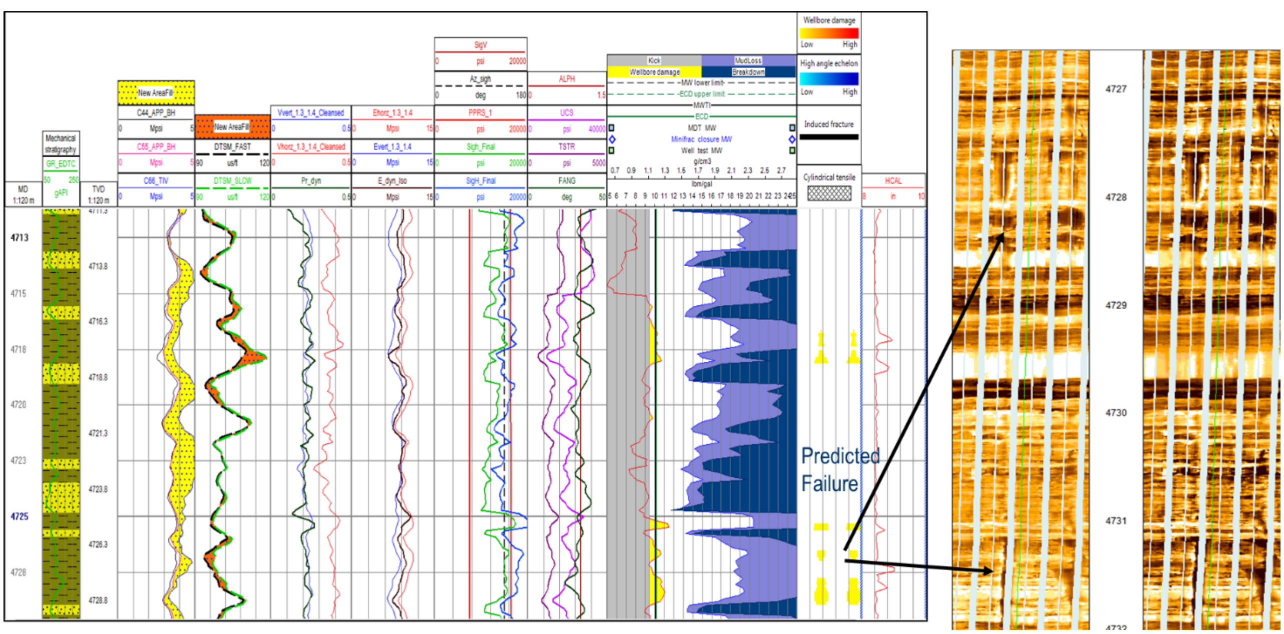

Figure 2: Good match of predicted breakouts using anisotropic MEM with borehole image