Integrated Geomechanical Analysis to Predict the Behavior of Naturally Fractured and Laminated Reservoirs During Hydraulic Fracturing

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Summary

Case studies are presented that describe the challenges and benefits of an integrated geomechanics approach in the tight gas Montney laminated siltstone and Confidential tight oil fractured shale reservoirs of western Canada.

Introduction

In situ stress evaluations were completed in multiple subject wells in each field by integrating core-calibrated logs, stress inversion from image logs, pore pressure from buildup tests, and fracture closure pressure from minifracs. The magnitudes and orientations of principal stresses were established in each subject area with a low degree of uncertainty.

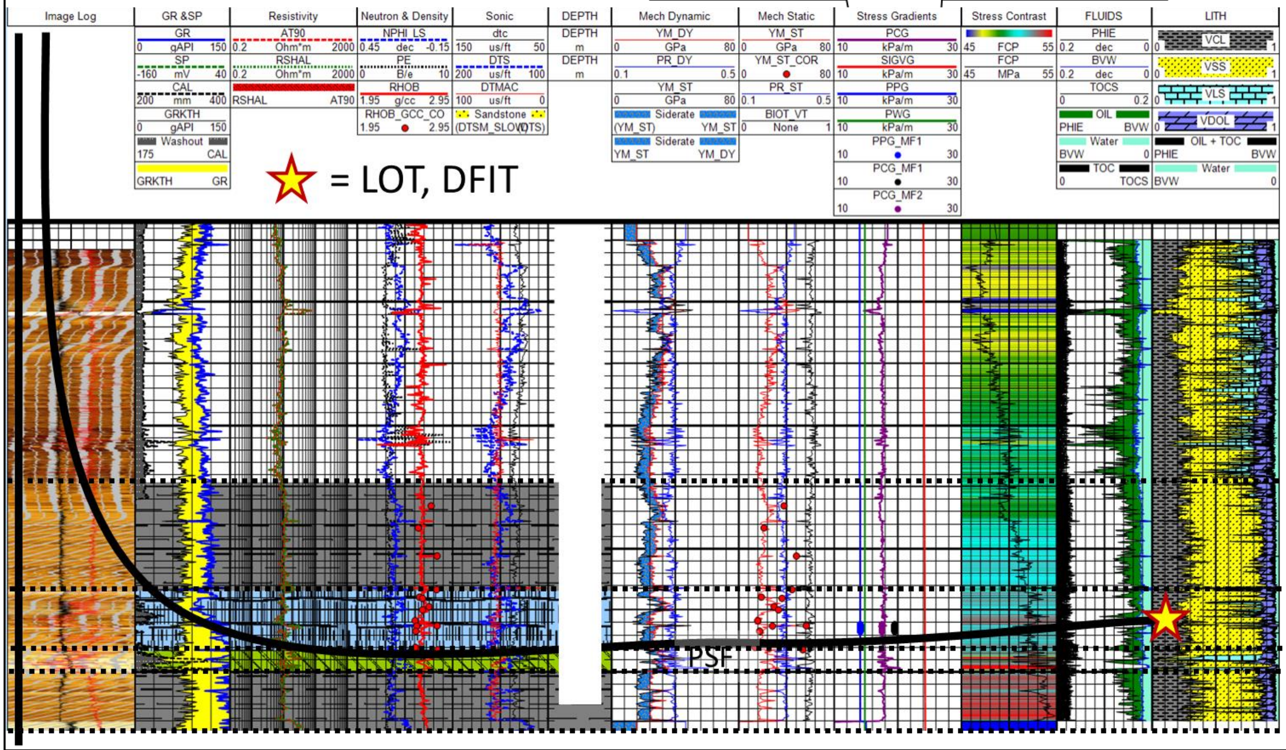
Theory and/or Method

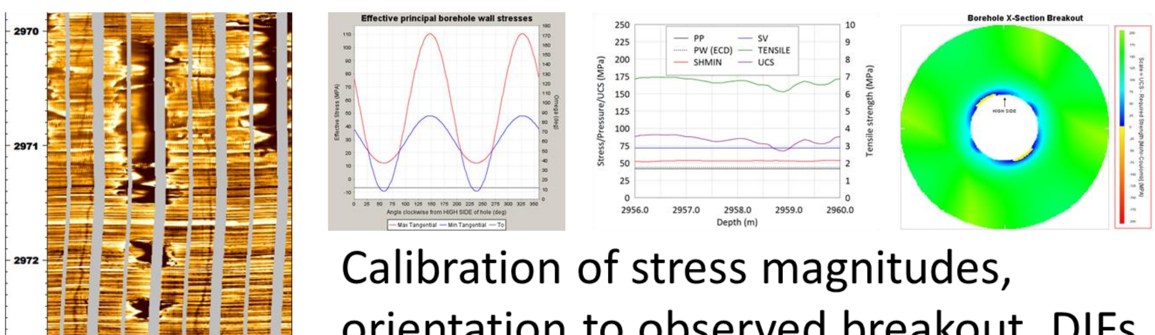
Natural fractures and weak laminations were characterized in detail at the wellbore scale using image logs and core. Relationships between fracture/lamination type, surface roughness, shear strength, in situ stress and permeability were established. Both analytical and numerical discrete element models were used to predict the response of these fractured/laminated zones to fracturing and injection scenarios. Results indicate that dilational shear behavior of fractures and intact laminations, with associated enhanced permeability, may be a relevant feature in these reservoirs despite their great depth. Customized diagnostic injection tests were run in the subject wellbores with both holistic and pressure transient analysis techniques used to analyze flowback data. Analysis shows that fluid was flowing back to the well along stimulated natural fractures or weak laminations as the geomechanical model predicted.

Examples

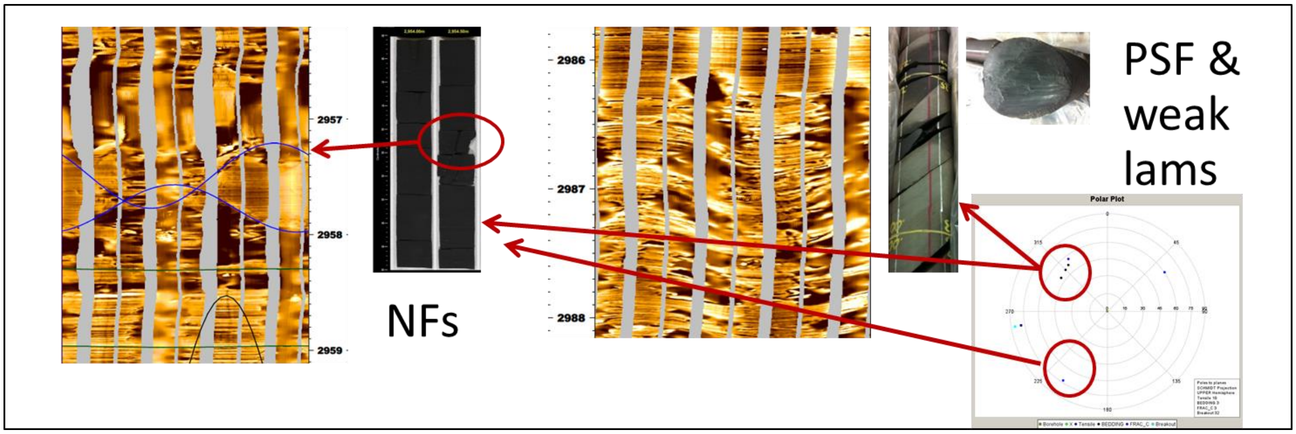
Pilot: core-calibration, image logs, NF study, MEM

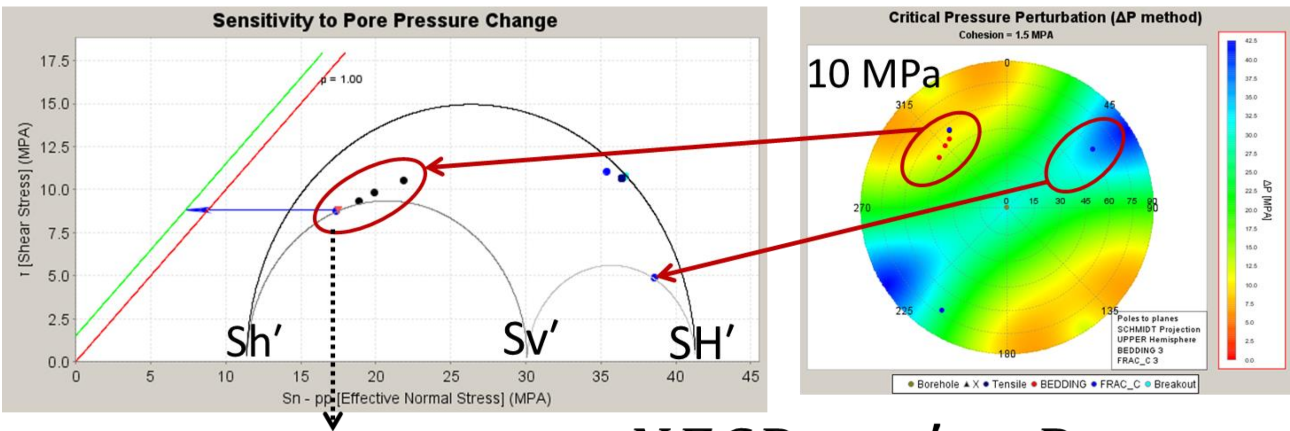
Lateral: LOT, DFIT





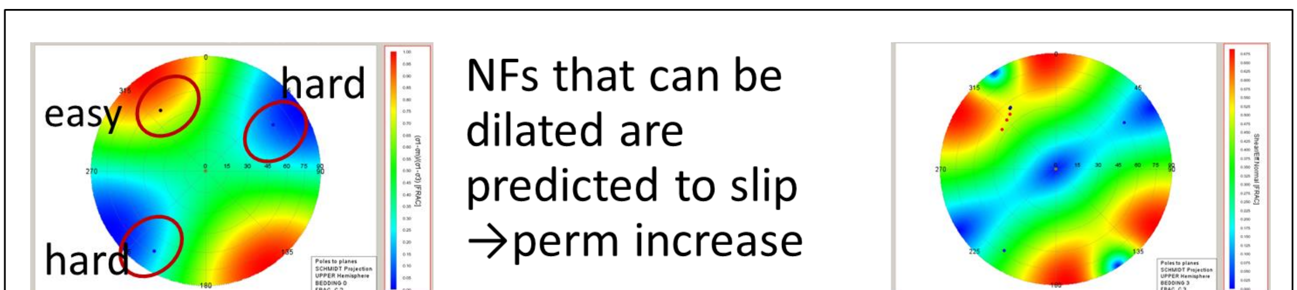
Calibration of stress magnitudes, orientation to observed breakout, DIFs





$\sigma_n' = 16.8$ MPa

$$NFCP = \sigma_n' + P_p$$



$$Dilation\ Tendency = \frac{(\sigma_1' - \sigma_n')}{(\sigma_1' - \sigma_3')}$$

$$Slip\ Tendency = \frac{\tau}{\sigma_n'}$$

Conclusions

Implications depend on whether such stimulated features are beneficial (production from the Confidential fractured shale depends on this) or detrimental (offset frac hits and limited height growth are associated with this in the Montney). Strategies are discussed for mitigating or exploiting these scenarios as guided by the integrated model results.