SPE159262 – Laboratory Testing and Numerical Modelling of Fracture Propagation from Deviated Wells in Poorly Consolidated Formations

Ion Ispas, Robin A. Eve, Randall J. Hickman, Richard G. Keck, BP, Stephen M. Willson, BP now with Apache, Karen E. Olson, BP now with Southwestern Energy

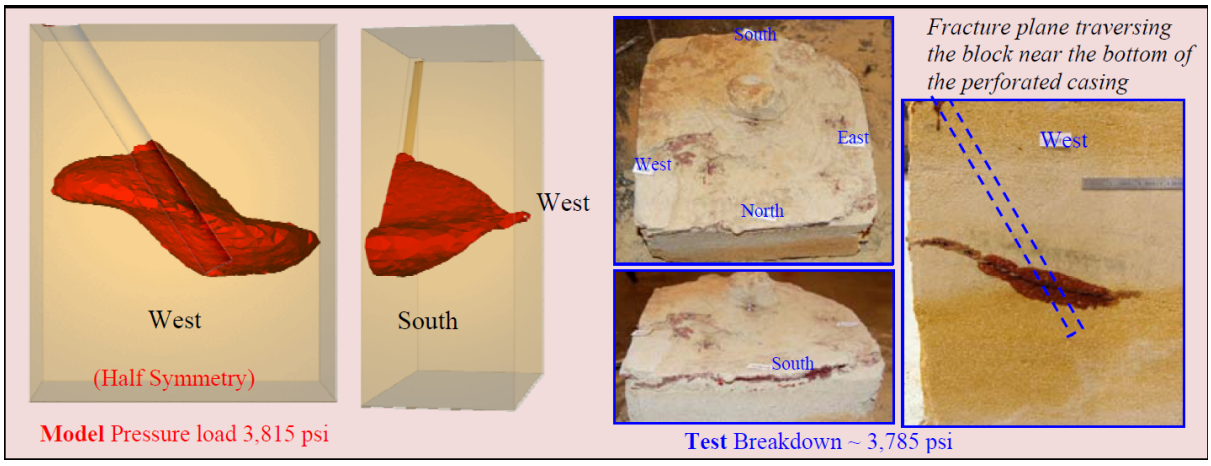
Abstract

This paper presents the results of an integrated laboratory and numerical modelling study on the effect of wellbore deviation and wellbore azimuth on fracture propagation in poorly consolidated sandstone formations. The goal of this project was to develop an understanding of how fractures would transition from single planar fractures to non-planar transverse fractures for fields in the deep-water Gulf of Mexico.

The foundation of this work was over 40 fracturing laboratory tests to measure fracture geometries for a range of well deviations, differential horizontal stresses and rock strength. The samples tested were from three outcrops with unconfined compressive strength (UCS) values ranging from 300-1000 psi. For boreholes having low deviation angles and small differential stresses a vertical single planar fracture became mode complex, with transverse turning fractures no longer aligned with the wellbore.

These laboratory results were used to develop and calibrate a new fully-3D finite element model that predicts non-planar fracture growth, using the finite element code ELFEN. The model matches the details of the laboratory tests, including the transition from planar vertical to non-planar transverse fractures as the well deviation, azimuth and stress differentials increase. After initial model development and calibration was complete a model of a complex case was run before showing any experimental results to the modellers. The model successfully predicted the transverse non-planar results found in the laboratory; this gave us increased confidence in the model as a predictive tool.

This work has now been applied with excellent success to four deep-water fields. We have recommended changes in maximum well deviations, performed post-job analyses on well that had high deviation, and have increased our understanding of the impact of layered formations in fracture growth in these fields.



Numerical results (left) showing good correlation to laboratory results (right)

Link: http://www.apachecorp.com/Resources/Upload/file/innovation/Ispas-Laboratory_testing_and_numerical_modelling_of_fracture_propagation.pdf