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Structural Modeling in a Non-Conventional Fractured Basement Reservoir

CONTRIBUTED BY PARADIGM AND NFR STUDIES GMBH

In 2012, a joint venture based in Ho Chi Minh City needed to conduct a technical study to characterize, model, and flow-simulate a nonconventional fractured basement reservoir located offshore Vietnam.

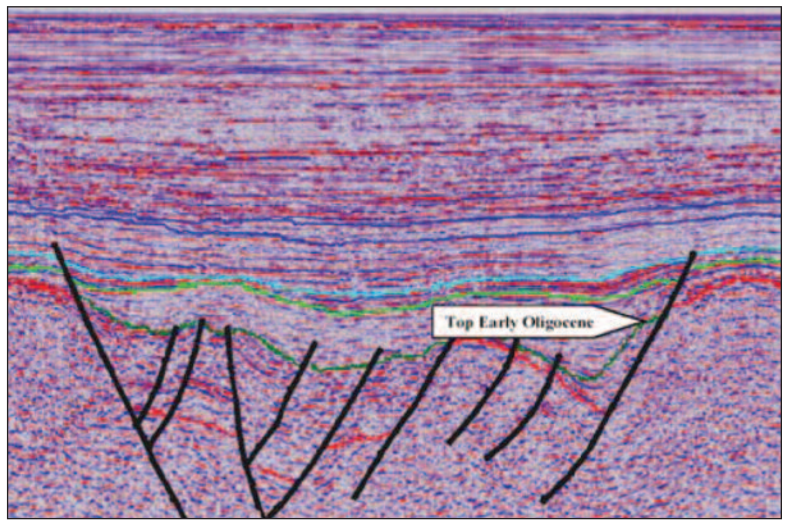
Predicting production using standard reservoir simulators had been problematic for the company. The difficulty was in building an accurate reservoir model that could run a realistic flow simulation using pillar-based modeling tools. A new reservoir model and simulation workflow was needed to capture its structural complexity, rock properties, and dynamic behavior.

This reservoir shares many of the traits of naturally fractured reservoirs (NFRs), with large well rate variability, rapid pressure decline and interwell communication, and early water breakthrough, leading to a prohibitive water cut. Faults and fractures control fluid flow, particularly in granitoid host rocks with only marginal porosity.

The field contains complex intersections between faults (Y and X contact shapes, etc.), between horizons and faults (reverse faults, important offset of the basement on the flanks), and between horizons (the top of the basement is an unconformity). Only a few faults had been kept in the structural model, oversimplifying the reservoir grid and thus failing to capture realistic flow behavior. While a wealth of geophysical and other relevant data had been collected to help clarify the situation, these data were underused because they were difficult to represent in such models.

A decision was made to build a new structural framework model using SKUA that properly honors all fault intersections, conditions that were not met by standard modeling tools. A sector scale model was studied. Fifty-three original fault interpretations were included, and all were excluded in the model.

The modeling solution used created a watertight structural model, meaning that it is composed of surface-delimited sub-volumes in which the surfaces are welded together without any holes. This structural model can be transformed into a set of triangulated surfaces that share nodes on the contact lines. This is an important prerequisite for unstructured volumetric meshing as part of the simulation workflow.



This is a typical seismic profile in the Cuu Long basin. The top basement (red) is highly offset by major normal faults; the sedimentary layers are lying on the top and flanks of the basement highs, with stratigraphic unconformities (black arrows) where top Early Oligocene (dark green) is not present and Late Oligocene layer (light green) lies directly on top of the basement. (From Hung and Le, 2004; image courtesy of Paradigm)

The modeling of the top basement and top of sediments was performed in a single operation. The contact of the sediments on the top basement was handled automatically through use of the stratigraphic column (unconformable contact between the basement and the sediments) and the nondepositional curve. The resulting horizons were smooth and clean while preserving the complexity of the fault network. At the creation of the triangulated surfaces, fault throws smaller than a given target refinement-based threshold were merged automatically to prevent the creation of very small degenerated elements.

The sector scale model was generated in less than a week. No structural model had ever been built for this field before this study because no software could properly handle representation of the faults. By creating the structural model and performing quality control on the seismic data, many refinements and updates could be made to the interpretation. Questions about fault extensions within the sediments could be answered for the first time.

Thanks to the preservation of all the faults in the model and the analysis of the vertical and lateral extent from the basement to the surrounding sediments, precise flow pathways were identified in the reservoir. ■