Evaluating Structural Control on Clastic Reservoirs Fluid Distribution

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Abstract

Objective
Faults can impose challenges in evaluating reservoir connectivity as they have the potential to form seals against fluid movement, with implications for reserves estimates, field planning and drilling optimization. Fluid phase changes between two wells (X and Y), situated only less than 2 km apart and targeting a Paleozoic clastic reservoir in the Arabian basin, instigated the evaluation of potential fluid discontinuity (i.e., compartmentalization) within the reservoir. Here, structural analysis is performed on a NW-SE trending fault affecting the reservoir to investigate its potential role in forming separate fault blocks and compartmentalizing the reservoir.

Methodology
Structural analysis was utilized to (1) define the extent of the fault to establish whether it can potentially separate the reservoir into different compartments through linking with another, larger, fault trending NNE-SSW, and (2) evaluate the fault sealing potential in terms of reservoir-seal juxtaposition and fault rock sealing. Seismic reflection data, seismic Variance attribute and fault throw profile analysis were used to define the lateral fault limit. The sealing potential of the fault was first assessed by constructing juxtaposition and clay content profiles (shale-gouge ratio (SGR)) calculated and extracted from a simple facies model based on gamma-ray lithology classification. These along-fault plane profiles help delineate potentially leaking and sealing zones. To address the uncertainty related to seismic resolution, the influence on sealing potential was investigated by applying the juxtaposition and SGR analyses on different geological models with different sub-seismic fault displacements. The results are checked against outcomes from gas chromatography (GC) fingerprinting and Pressure-Volume- Temperature (PVT) analysis, performed in parallel with the structural analysis.

Results
The seismic attributes and fault throw analyses both indicate that the fault in question does not link with the NNE-SSW fault and, therefore, is not likely to fully separate the reservoir into different compartments.

Furthermore, the results of the juxtaposition and SGR fault seal analyses applied on the different sub-seismic fault throw scenarios suggest that the reservoir sandier facies are likely to be continuous across the fault regardless of the chosen vertical displacement. That is, more shaly layers within the bulk reservoir rock are not thick enough and not likely to be continuous over tens of kms to significantly contribute to sealing by juxtaposition, forming high-shale content fault rock, or being smeared along the fault.

Conclusions

The outcomes of the structural analysis indicate the lack of evidence for fault-controlled compartmentalization between wells X and Y. This conclusion here is aligned with fluid data derived from gas chromatography (GC) fingerprinting and Pressure-Volume-Temperature (PVT) analysis. This paper showcases a workflow that reduces uncertainty in reservoir compartmentalization analysis by applying fault sealing analysis on different scenarios of fault displacement, and evaluating the results in light of, and integrating them with, independent geochemical analyses to constrain the cause of fluid phase changes. The conclusion drawn here is expected to impact reservoir connectivity assessment and further field development.