Seal-Integrity Analysis of a Thrustbelt Anticline in the Lesser Caucasus Foothills, Georgia

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Abstract

A prospect-scale 3D structural and seal-integrity assessment was conducted on a W-E oriented, and partially fault-dependent, thrustbelt anticline, located in Block XIb in the foothills of the eastern Lesser Caucasus, Georgia. The anticline is hosted within a prospective north-vergent duplex stack. The main objective of this structural evaluation was to quantify the sealing capacity of the two southern bounding faults of the anticline.

Firstly, a high-level QC of the key structural elements of the prospect was conducted. Secondly, a detailed fault- integrity analysis was carried out, using state-of-the-art workflows. We integrated 3D seismic (depth domain), 2D seismic (depth domain), key wells, existing seismic grids, existing picks of fault planes, digital terrain data, surface geological data, cultural data, as well as public and internal reports.

The review also covered the geometry of the stratigraphic horizons within the prospect, to ensure accurate representation of the subsurface structures. Based on this review, we made adjustments to the grid of the Middle Eocene and the fault planes to refine the structural framework, which is essential for the subsequent fault-seal modeling. A standardized lithostratigraphic column was generated, based on petrophysical data. This served as fundamental input data for the fault-integrity models. Various geometric and kinematic assessments were carried out using state-of-the-art structural modeling software. Finally, several fault seal proxies were modeled for two different scenarios: “sandy” Lower Eocene and “shaly” Lower Eocene.

Our analysis revealed the following key observations: (a) both faults exhibit different geometries, kinematics and sealing potential, (b) the master fault is much larger (laterally and vertically) and steeper than the secondary fault, (c) lithological juxtaposition at the main fault appears to be more favorable than at the secondary fault, (d) shale gouge ratio values are higher at the main fault than at the secondary fault, (e) clay smear potential values are high at both faults, but somewhat more favorable at the main fault. In summary, both faults appear to have good sealing capacity, however, the main fault exhibits a higher sealing capacity than the secondary fault.

Some model and data uncertainties remain, as follows: (a) The prospect is only partially covered by 3D seismic data, (b) no direct observations (well penetrations) of the bounding faults exist, (c) lower Eocene strata are known to be fractured, a complexity that was not quantified in this evaluation, (d) the mineralogy of the clays in the assessed area was not available for this analysis. Future evaluations of this prospect should include a full 3D seismic interpretation of the key 5 stratigraphic horizons with a particular focus on the connection zone of the two bounding faults. Strain analysis of the hanging-wall block (to improve understanding of fracture behavior) and seismic attribute analysis (to detect small-scale faults) would further refine the model.