Validation of a 3D Geomechanical Model in Wildcat Exploration: A Case Study

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Abstract

Drilling wells in frontier settings poses significant challenges in planning and safe execution. Key issues such as pore pressure and fracture gradient prediction or assessment of fault stability are difficult to approach in these settings due to the scarcity of accurate data with which to calibrate models. Nonetheless, the exercise of 3D geomechanical modeling constrained by different sources of qualitative or partially quantitative data can provide very useful insights into elements of significant impact to safe drilling. Here we present the case study of a well drilled over a salt structure in a deep-water setting, in a basin in which the nearest offset well had been drilled hundreds of kilometers away. Pore-pressure and fracture gradient predictions based on offset well analysis were used to constrain a finite element geomechanical model for the prospect that was used to estimate the present-day 3D stress distribution. The results indicated the relative stability of the faults to be drilled. Modeling also revealed that faulting above the salt structures is related to gradual deflation of the salt body on the scale of hundreds of years and that the process of salt motion is causing stress arching above the salt body. Drilling of the well became the ultimate test of the validity of the observations made on the geomechanical model. Firstly, drilling demonstrated that all faults were stable, as no measureable losses or changes in drilling conditions were observed across them. Secondly, and more critical in terms of decision making while drilling, as the well approached the top of the salt body, losses started being recorded with mud weight 1ppg below the predrill fracture gradient. Different integrity tests and loss events returned values for the fracture gradient that were either in line with or 1ppg lower than the geomechanical model stress magnitude estimate. Integration of stress analysis based on enhanced natural fractures identified in the well confirmed that the most likely scenario was that of lower stresses. This conclusion was used to update the pore pressure prognosis and complete the safe drilling of the well.