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4D Geomechanical Study Helps Drilling Operations in North Kuwait Giant Reservoirs

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ABSTRACT

North Kuwait has had mature giant reservoirs on production for the last six decades. The reservoirs are vertically stacked over a depth of 12000 ft separated by barriers. All have an accelerated plan of development, mainly with non-conventional wells. Some wells were successfully drilled while the recent wells have faced severe drilling problems leading to stuck pipe leading to side-tracking. While time-dependent shale instability is suspected as one of the main contributors to these drilling problems, the profiles of existing wells indicated that the combined effect of in-situ stress and well trajectory on wellbore stability should also be thoroughly investigated.

Comprehensive analysis of static and dynamic data was undertaken to build 4D coupled Geomechanical models of different scales for all the producing reservoirs of the North Kuwait fields. The 4D geomechanical model provided the equilibrated stress variation with production. In situ stresses vary laterally and vertically as well as with pore pressure changes, so the wellbore stability during drilling needs to be addressed at field and wellbore scales to optimize well trajectories and to define safe mud weight windows. In addition, horizontal wells did intersect fault zones leading to fluid losses, and fault reactivation posed potential risks. The shale layers are intersected during drilling and exposed to long open-hole durations, where mechanical and time-dependent wellbore stability issues have been observed. Therefore, wellbore stability predictions, mud weight programme recommendations and mitigation of time-dependent shale instability for future horizontal wells are critical for successful drilling and completions operations.

The 3D geomechanical modeling results were used to generate 3D mud weight cubes, which for every cell in the model established the width of the stable mud weight window based on the difference between the breakout limit and the mud loss limit or breakdown limit. Depletion and injection cause changes in horizontal stresses, and such changes induce changes in the drilling mud weight, requiring an updated mud weight cube. In addition, the optimum inclination and azimuth that lead to widest stable mud weight window were calculated. The output will provide general guidelines on optimum wellbore direction for different formations and locations of the field. More than 15 newly planned wells were drilled successfully in Zubair, Burgan and Mauddud with reduced Non-productive Time.