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Understanding Wellbore Stability Challenges in Horn River Basin

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Abstract

Wellbore instability related problems cost the industry hundreds of millions of dollars each year. Drilling cost could be substantially reduced if predictive wellbore stability analysis is conducted prior to drilling as part of proactive well planning. Shale formations are one of the primary sources (90%) for wellbore instabilities. Shale formations have laminated structures which result in significant differences in mechanical properties along the orientations parallel to and perpendicular to bedding planes. These differences can lead to anisotropic estimated horizontal stresses. Failure to consider the effect of anisotropic behavior of shale can have severe consequences for drilling. In rocks with anisotropic mechanical properties and strength, there is a high risk of wellbore instability while building deviation angle from vertical sections. Moreover, the approaches typically used in wellbore stability analysis do not consider the material anisotropy, the inherent heterogeneity and the laminated nature of shales, which can result in wrongly estimated stresses leading to incorrect safe trajectory or mud-weights. Minimizing such potential risks is key to optimizing drilling and production economics. Numerous wellbore instability problems have been reported in the Horn River Basin (HRB), the largest gas shale field in Canada. Most of the drilling problems we have analyzed in the HRB have occurred while building angle.

In this paper, the effects of shale anisotropy on rock mechanical properties and wellbore stresses are highlighted. Drilling challenges encountered in the HRB and effective ways to avoid or minimize such problems are discussed in detail based on several case studies. In these case studies, operators faced severe drilling challenges; they had to halt or alter their planned trajectories or sidetrack to avoid problematic zones. We performed an in-depth post-mortem analysis of these wells, identified possible causes for these problematic zones, and made appropriate recommendations for avoiding or minimizing such problems in future drilling. Three of the key reasons identified are: (i) shale anisotropy was not properly characterized; (ii) anisotropic horizontal stresses were not considered in the pre-spud analysis, which resulted in incorrect mud-weight window and trajectory calculations; (iii) attack angle with respect to shale bedding planes at build sections was not appropriate with respect to shale stability.

Some of the conclusions drawn from these case study examples are: (i) To compute in-situ stresses accurately, 3D azimuthal anisotropy of shale should be properly characterized; (ii) Optimal well trajectory and safe mud-weight window for wellbore stability should be computed by considering anisotropic in-situ stress; (iii) The attack angle with respect to shale bedding planes must be more than 20°; and (iv) Shale generally undergoes time-dependent and progressive failure; hence the shale exposure period between drilling and casing must be minimized.