SPE 110742

Wellbore Stability Considerations for Drilling High-Angle Wells Through Finely Laminated Shale: A Case Study From Terra Nova

Chris Gallant, SPE, Petro-Canada; Jianguo Zhang, SPE, BP (formerly Baker Hughes), Christopher A. Wolfe, SPE, Baker Hughes, John Freeman, SPE, Baker Hughes, Talal AL-Bazali, SPE, Kuwait University, and Mike Reese, SPE, Baker Hughes

This paper was prepared for presentation at the 2007 SPE Annual Technical Conference and Exhibition held in Anaheim, California, U.S.A., 11–14 November 2007.

Abstract

High angle wells drilled into finely laminated shale are often found to be less stable than comparable wells drilled into non-laminated rock. This can be attributed to a variety of factors including, but not limited to, well trajectory, the in-situ stress field, rock strength anisotropy, shale reactivity issues, chemical imbalances between the drilling fluid and shale pore fluid, and many others. However, due to the lack of available data some of these mechanisms are difficult to quantify and therefore are typically not accounted for during well planning. This can result in significant wellbore instability issues that substantially elevate drilling operation costs.

In this paper, a comprehensive approach to account for many of these wellbore instability mechanisms is outlined. A plane-of-weakness model is utilized to account for the effects of weak bedding planes and other discontinuities. The model uses parameters that are obtained by curve fitting triaxial strength test results conducted at various angles with respect to bedding. Additionally, traditional mechanical and chemical effects were also addressed and incorporated into the pre-drill model to assist in well planning. The model was then implemented at the Terra Nova field for the case of a highly deviated wellbore drilled through finely laminated shale nearly parallel to bedding.

Real-time monitoring of measurement and logging while drilling data was key to identifying the unstable sections so that the root cause of instability could be diagnosed. The appropriate remedial action was then applied and wellbore instability problems were mitigated.

Both mechanical and chemical borehole instability models were applied in a case history to evaluate the potential for wellbore instability. In particular, bedding-plane related and chemically-induced instability were addressed and overcome through comprehensive modeling and the deployment of modified operational procedures.

Introduction

Wellbore instabilities have plagued the drilling community within the petroleum industry for many years. Despite the development of sophisticated borehole stability models designed to mitigate wellbore instabilities, the amount of wellbore instability-related incidences still exceed 40% of drilling non-productive time (NPT) and account for nearly 25% of all drilling costs[1]. These result in estimated annual wellbore stability-related expenditures in the order of billions of dollars worldwide. This sort of NPT can seriously jeopardize project economics and therefore it is of critical importance to reduce instances of wellbore instability.

In this paper, we will first outline some wellbore instability mechanisms that need to be considered when drilling high angle wells. The intent is to accentuate some of the borehole failure mechanisms relevant to extended reach drilling (ERD) wells. Additionally, a modified anisotropic strength model is used in a successful case study highlighting drilling experiences of several high angle ERD wells from the Terra Nova field.

Wellbore Instability Mechanisms in High Angle Wells

It is well known that instances of wellbore instability increase in high angle wells[2-6]. This is usually attributed to mechanical failure of the rock due to unfavorable orientation of the wellbore with respect to the in-situ stress field. The result is a significant reduction in the safe mud weight window leading to premature shear and/or tensile failure. These types of failure mechanisms have been well documented in the literature and will not be discussed again here.

In addition to the traditional mechanical failures it is also necessary to consider chemical, thermal and poroelastic failure mechanisms. Chemically-induced instability manifests itself as a reduction in the rock strength, elastic modulus and/or a change in the near wellbore pore pressure which can appreciably alter the safe mud weight window[7-14]. Also, the thermal potential that arises due to temperature differences between the drilling fluid and formation can also cause changes of the wellbore effective stresses leading to a