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Wellbore Stability Predictions using Mechanical Earth Model - A Case Study for Okan Field, Offshore Nigeria

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Abstract

Okan field is one of the oldest fields being developed in offshore Nigeria. Geomechanics challenges with further development include drilling through severely depleted shallower reservoirs, high-angle penetration through sloughing shales, and horizontal wells. Significant downtime due to tight hole, packoff, and stuck pipe was experienced in several wells drilled recently, which resulted in significant extra capital expenditure.

After reviewing relevant data from the field, a 1D Mechanical Earth Model (MEM) was established. It was found that the Okan field generally has a benign stress environment without clear maximum horizontal stress orientation, indicating no significant horizontal stress anisotropy. Rock mechanical properties were calculated with wireline/LWD logs based on a Rock Mechanics Algorithm (RMA) that is closely linked to Chevron's worldwide rock mechanical property database. Consequently, even when there were no core test data available to calibrate RMA predictions directly, the log dataset provided the means to estimate reliable formation mechanical property values that are consistent with Chevron's worldwide database. Furthermore, the entire MEM was calibrated against offset data, resulting in a high degree of confidence in the predicted values. A lookback on the drilling history indicated that drilling problems were mostly caused by low surface mud weights for high-angle wells, combined with incorrect ECD management. As such, recommendations on downhole mud weight and well design were made to mitigate future wellbore stability related problems. Wellbore collapse mud weights were predicted and recommended for new wells based on this study. Drilling experiences review of the newly drilled wells indicated that wellbore stability related problems were significantly reduced, proving the efficacy of the MEM.

Introduction

Okan field is one of the oldest shallow offshore fields being developed in Nigeria (see **Figure 1** for field location). With increasing demand of oil, an aggressive drilling campaign was launched to drill more infill wells and to explore deeper targets. Geomechanics challenges with further development include drilling through severely depleted shallower reservoirs, high-angle penetration through sloughing shales, and horizontal wells. Significant downtime due to tight hole, packoff, and stuck pipe was experienced in several wells drilled recently, which resulted in significant extra capital expenditure, especially at record-high rig prices.

In this paper, drilling problems from a few wells (**Figure 1**) in the Okan field were briefly described. Afterward, it was illustrated how a field-wide 1D MEM was established. It was then demonstrated that the 1D MEM could be used to explain wellbore stability related problems encountered during drilling. It was also shown that predicted mud weights from the well-calibrated MEM contributed to trouble-free drilling of new wells. Finally, conclusions and recommendations were made based on this study.

Drilling Problems

Four wells in the field were studied in this project. They were Okan 100P/100HST1, Okan 101H, Okan 105H and Okan 110P/110HST1/110HST2 (see **Figure 1** for relative well location). Among those wells, the Okan 100P/100HST1 well had drilling problems such as tight hole, packoff and stuck pipe in both the pilot hole and the sidetrack. For twice the stuck pipe problem occurred when the pump was off. See **Figure 2**. The Okan 101H well was done without any trouble. The Okan 105H well only had some tight spots when tripping in and out of the hole, but it was completed without major problems. See **Figure 3**.

The Okan 110P/110HST1/110HST2 well had BHA and