Operator Successfully Drills Troublesome Clays with Inhibitive Water-Based Mud

BARA-HIB™ GOLD TRACKABLE INHIBITIVE SYSTEM DELIVERED EXCELLENT WELLBORE STABILITY IN HIGHLY REACTIVE CLAYS

NORWAY

CHALLENGE

- Drill and case off reactive Pliocene and Upper Miocene shales
- Prevent gumbo attacks
- Prevent bit balling and downhole losses
- Prevent shale swelling to allow casing strings to be run and cemented at depth
- Achieve effective hole cleaning in large-bore intervals

SOLUTION

- Customized BaraHib® Gold fluid system to inhibit reactive shales
- Extensive qualification process to validate fluid capabilities to suppress shale swelling, accretion, and erosion performance

RESULTS

- Successfully drilled the first WBM sections in the field in over 20 years
- Drilled 17-½" x 20" section with limited flow rate and solids control equipment
- Ran 17-in. liner and cemented without losses
- Hole slick and cased off

OVERVIEW

The Pliocene and Upper Miocene shales in a mature Norwegian oil field had not been drilled with water-based mud (WBM) for over 20 years. Historical offsets noted the abrupt end of use for these fluids after well sections experienced severe shale stability problems. These included gumbo attacks and bit balling, which added time and compromised drilling objectives due to induced losses and poor cement jobs. Sidetracks were commonly needed to reach the reservoir. The overlying Pliocene section is a large diameter interval requiring a fluid density of 10.2 ppg. The underlying 16-in. section requires a density of 12.9 ppg in order to remain above the collapse gradient as the section builds to an inclination of 50 degrees at target depth (TD).

Although non-aqueous fluid (NAF) systems are clearly well suited for drilling such a highly-technical field, they incur a host of operational expenses for slops and cuttings waste associated with containment, transport, and treatment phases. These ancillary costs have continued to increase in magnitude over time and offset some of the economic gains from added field production, especially in this case since the remote wellhead platform was located away from the main field's cuttings injection infrastructure. This prompted the operator to trial Halliburton Baroid's BaraHib™ Gold high-performance WBM (HPWBM) in an attempt to significantly reduce their NAF waste management costs.

CHALLENGE

Shales within these zones are mostly hydratable clays—typically composed of between 30-50% smectite, 10-30% illite, and 10% kaolinite. Cation exchange capacity (CEC) tests indicated results between 5 and 20 meq/100 g, with increasing reactivity with depth (Figure 1). This all meant that a very inhibitive WBM design would be required, and the field maintenance practices during drilling would have to ensure that the levels of key inhibitor components were kept up.

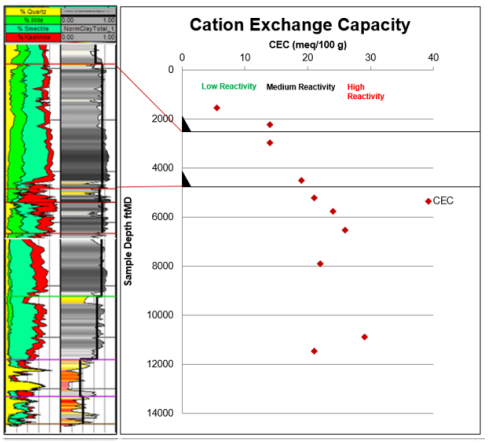

Figure 1. CEC values for well profile.

Additional infra-structure challenges were also encountered, which required adaptive engineering practices and close attention to detail:

- One mud pump was out of service, limiting flow rates.
- The centrifuge was out of service, meaning increased solids content as drilling progressed.
- Critical rig equipment broke down at the end of the 16-in. section, resulting in suspension of operations until it could be fixed.

SOLUTION

An extensive fluid qualification process was initiated at Baroid's Tananger Laboratory. A customized BaraHib Gold fluid system was developed for each section and qualified against formation samples obtained from previous activity. Capillary suction time analysis of various KCl brine concentrations aided in determining the optimum salt concentration for the base brine. The BaraSure™ W-674, BaraSure™ W-546, and GEM™ GP package was optimized to give extremely low shale accretion values (less than 1% by weight on the most reactive shales), while shale swelling was controlled at 11% or less.

The final formulations were approved by the customer, and the well was designated a Critical First Well to ensure global focus within the Baroid organization. In addition to the qualification process, BaraSure W-674 concentrations were tracked to control depletion and maintain optimum concentration while drilling. The cuttings (Figure 2) were dry inside and had visible cutting marks on their exterior, demonstrating a high level of ongoing inhibitive performance.

OPERATIONS LOG

- Two sections were drilled, a 17 ½" x 20" section and a 16" section.
- When the rig's mud pump was down, Halliburton Baroid's Applied Fluid Optimization team played a huge role in ensuring acceptable hole cleaning was maintained.
- The ability to predict the fluid's rheology profile throughout the wellbore enabled the operator to drill to TD in a controlled fashion, without major issues.
- Several high-viscosity pills were pumped at TD and at the casing shoe prior to pulling out. This proved to be effective despite the insufficient flow rates.
- With the rig's centrifuge inoperable, Baroid was again challenged to maintain fluid properties by the addition of fluid premix and direct chemical additions throughout the drilling operation.
- After reaching TD on the 16-in. section, a malfunctioning fire water pump resulted in an additional three days of exposure time for the open hole. The operator was already planning to sidetrack this section due to expected integrity failure. However, when running back into the well after fixing this equipment, the wellbore proved slick with no signs of swelling or other constrictions.
- The fluid rheology was reduced towards the section TD, which was effective for cementing the liner and casing without any downhole losses experienced.

Figure 2. Drilled cuttings shown on shaker deck.

RESULTS

Both sections were drilled uneventfully, in spite of the challenges which were expected and not those which were not anticipated, and the liners were run and cemented without a hitch. As a result of this successful trial, the concept of using HPWBM for remote drill centers was approved, considerably reducing NAF cuttings handling and disposal expenses. The estimated future savings are calculated to be USD 500 K - 1 MM less per well, compared to oil-based mud.

This first-time trial demonstrated to the client that problematic upper sections can be drilled effectively with HPWBM. Two remote wellhead centers will be exploited in the future using the BaraHib Gold solution, with the potential to realize significant savings for the operator of between USD 4 MM and 8 MM for a planned 8-well campaign.

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