Case History

Hydros™ High-Performance Water-Based Drilling Fluid System with Customized Chemistry Enables Successful Drilling of Highly Challenging Wells, Offshore Montenegro

Newpark's deep domain expertise and experience in the region ensured these highly challenging wells were drilled successfully and economically with water-based fluids.

CHALLENGE	SOLUTION	RESULT
• Offshore drilling campaign in environmentally sensitive area • Challenging geology • Wellbore instability anticipated, exacerbated by high overpressure and high temperature gradient • Operator expecting to use non-aqueous fluid (NAF) due to drilling challenges	• Extensive pre-project testing, analysis and planning • Customized Hydros™ high-performance water-based drilling fluid (HPWBM) • Customized environmentally-friendly spotting fluids to mitigate stuck-pipe events • Dedicated Liquid Mud Plant (LMP) facility	• Hydros™ system performed consistently to mitigate wellbore instability even at mud weight of 2.14SG (17.8ppg) • Water-based fluids reduced potential HSE impacts, with the added benefit of cost-efficiency • Stuck pipe events mitigated

OVERVIEW

Montenegro is one of the few untapped deepwater plays in the world. Newpark was chosen for the 2 well exploration drilling campaign in Montenegro because of our extensive global experience drilling deepwater wells and our recent successful experience drilling deepwater wells in the area, as well as our extensive logistics network and capabilities for developing facilities infrastructure.

Based on the exploratory nature of this campaign, Drilling in these fields is characterized by overstressed, over pressurized and unstable, tectonically stressed formations in a moderately high-temperature environment.

While non-aqueous drilling fluid (NAF) would typically be chosen on an exploration well, Newpark's leading position in advanced high performance water-based fluids (HPWBM), and track record with these fluids in deepwater globally, encouraged the operator to utilize HPWBM for this campaign.

CHALLENGE

Drilling in an environmentally sensitive area which is a tourist destination, combined with the operator's commitment to the environment meant that additional challenges would be addressed and anticipated for this complex offshore campaign

The operator required a water-based drilling fluid solution for this complex offshore campaign. However, wellbore instability was anticipated, exacerbated by high overpressure and high temperature gradient in the deeper sections.

There are many operational challenges which can occur with unstable formations, such as:

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- excessive cavings
- hole enlargements with consequent hole cleaning problems
- prolonged reaming, overpull, torque and drag
- induced losses for excessive equivalent circulation density (ECD)
- difficulties in running casing
- stuck pipe events that may require drilling costly sidetracks

Careful selection of the correct mud weight (MW) before drilling into specific formations is imperative to mitigate hole instability.

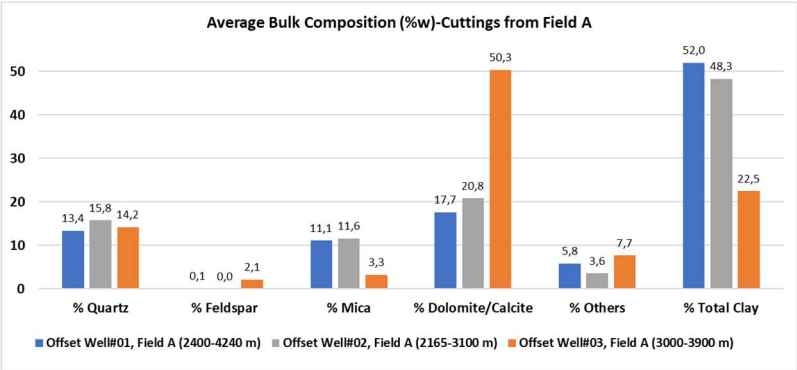
Minimizing pore pressure transmission by limiting the invasion of fluids and filtrate is important when designing the package of bridging and sealing agents for the drilling fluid formulation.

Shale formation instability represents one of the major technical problems during drilling, and it is a significant contributor to non-productive time (NPT) and unplanned project costs. Shale inhibition in water-based drilling fluids is critical to limit chemical interactions in shales formations.

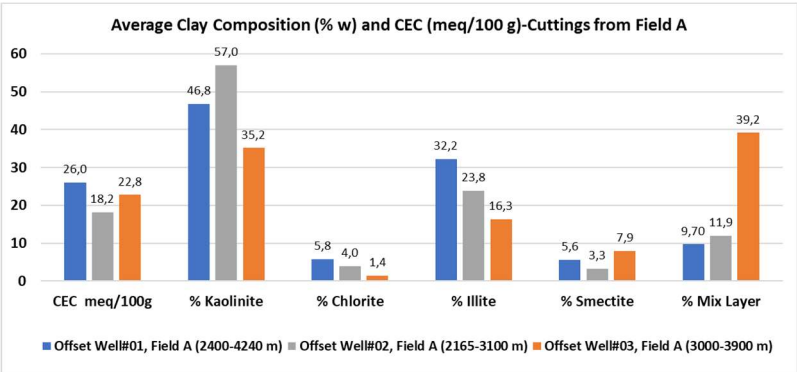
A thorough detailed analysis of data gathered from offset wells with instability issues drilled in nearby Albania and southern Italy was required to accurately design and formulate the drilling fluids program for this challenging campaign.

Some wells drilled in those fields faced severe borehole instability issues requiring sidetracks because of stuck pipe events and collapsing wellbores, contributing to unplanned NPT.

Drill cuttings received from offset Well#01 & Well#02 are each of clay, while cuttings from Well#03 presented a moderate clay content. The average cationic exchange capacity (CEC) values of all three wells are low to medium indicating moderate reactivity of the clays.



Graph #1: Bulk Composition of Cuttings from Offset Field



Graph #2: Clay Composition of Cuttings from Offset Field

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Mineralogy analysis of Well#01 indicated that the clay is mainly composed by kaolinite (non-swelling, some dispersion) and Illite (some swelling, dispersible) with minor components like Mix Layer (swelling, dispersible), Chlorite (non-swelling) and smectite (swelling).

The XRD analyses of cuttings from Well#02 showed that the clay is mostly composed by kaolinite (non-swelling, some dispersion) and Illite (some swelling, dispersible) with some mixed-layer (swelling, dispersible) and low content of smectite (swelling) as well as chlorite (non-swelling).

Mixed-layer (swelling, dispersible) and kaolinite (non-swelling, some dispersion) were major constituents of cuttings from Well#03 with presence of illite (some swelling, dispersible) and some smectite (swelling). Chlorite (non-swelling) is also present at very low concentration.

In addition to hole instability problems, other common drilling challenges associated with the drilling of wells in Field A are summarized as following:

- Potential contamination of surface aquifer
- Presence of hard, abrasive formation (like chert) resulting in low ROP and high torque
- Interbedded highly reactive clay
- Hole cleaning issues while drilling surface large hole diameter with partial losses
- Potential severe losses when changing formation
- Experiencing severe to total losses while drilling the fractured carbonate reservoir
- H_2S/CO_2 environment
- Severe corrosion with associated equipment damaging
- Environmental sensitive area with high-profile exposure – the area is a tourist destination, thus putting any event directly in the public eye

Figure 1: Cavings on shakers

Figure 2: Recovered cavings (angular, splintery & blocky)

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SOLUTION

An extensive laboratory testing program was developed to define these fluid formulations to fit with the challenges expected, taking all lessons-learned from the offset wells in the region.

Following the thorough analysis and testing work, Newpark's fluids specialist selected the Hydros™ high-performance water-based drilling fluid (HPWBM) customized with a chemistry package to optimize wellbore stability.

The Hydros system is designed to be customizable for these types of challenging geological formations. Wellbore instability concerns were addressed with additives for superior inhibition together with a bridging package to seal formation microfractures. A natural polysaccharide was included to maintain the rheological properties required for optimized hole cleaning. To further enhance drilling performance, specialized lubricants were included to reduce the friction coefficient while drilling.

Hydros was required to demonstrate excellent filtration testing characteristics, not only on the API HPHT but also on PPA with spur close to zero and minimum PPA total filtration value.

RESULTS

The Hydros drilling fluid system, with the customized package of shale inhibitors and high-performance drilling lubricant, performed consistently to mitigate wellbore instability even when the mud weight was increased to 2.14SG (17.8ppg) to control wellbore pressures. Despite its ultra-high density, the fluid exhibited excellent tolerance to both drill solids and to calcium ions while drilling the anhydride formation.

A pro-active sweep program was utilized with wellbore stability materials (WSM) incorporating bridging agents, anti-sticking and high viscosity additives. This safeguarded wellbore instability concerns, mitigated bit balling issues, and ensured the hole was properly cleaned.

During drilling operations, various differential stuck pipe incidents occurred most likely induced by the ultra-high mud weight. An environmentally-friendly, hydrocarbon-free, low-toxicity spotting fluid was deployed to resolve these unplanned events. By effectively soaking the contact area and penetrating between the pipe and wall cake, the fluid allowed the pipe to get free quickly.

X-Ray diffraction (XRD) and CEC analyses was also carried out on cuttings and cavings received from the well to map lithology of the field. Laboratory testing was also conducted on received rock samples to evaluate the inhibition properties of the drilling fluid to identify further optimization for future drilling projects.

Using the Hydros water-based drilling fluid system helped to achieve operational objectives safely ensuring the operator reached the well total depth (TD) while acquiring all necessary data for well evaluation.

Avoiding the use of oil-based fluid reduced the operator's cost, while reducing environmental impact and worker health & safety.

Furthermore, multiple differentially stuck pipe events due to the ultra-high mud weight were mitigated by implementing customized environmentally-friendly spotting fluids.

The fluid team implemented a customized lost circulation strategy that significantly reduced formation losses while drilling the reservoir section.

A dedicated liquid mud plant (LMP) and bulk facility were mobilized to the operator's supply base to provide rapid logistical support throughout the entire project.