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Uintaite-Based Blend Enables Replacing OBM when Drilling an Extended Reach Lateral in the Permian Basin Using WBM. Case Histories

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Abstract

A uintaite-based blend enabled a Drilling Fluids company to successfully drill a 2.5 miles section of an extended-reach (ERD) lateral well using water-based mud (WBM). The blend outperformed both oil-based mud (OBM) and traditional lubricant-based systems, maintaining mud properties (while combating a water influx), reducing filtrate volume, and forming a lubricious filter cake. Key drilling parameters such as rate of penetration (ROP), torque and drag, and non-productive time (NPT) improved, resulting in significant cost savings.

One of the primary drilling challenges in the Permian Basin is reaching total depth (TD) in extended lateral wells. Operational issues include wellbore instability, water influx, excess torque and drag, and fluid losses. Traditionally, these wells are drilled with OBM systems, but water influx can compromise OBM properties, threatening well integrity.

In one case, a drilling fluids company had to switch from an OBM to a WBM system due to an unexpected water influx. The WBM was designed with a novel uintaite-based additive, derived from naturally occurring asphaltite in the Uinta Basin's Green River Shale. Uintaite is a kerogen type I and contains organic nitrogen that stabilizes shale and exhibits amphiphilic properties—i.e. exhibits both hydrophilic and hydrophobic characteristics.

Following this success, the system has since been applied to a total of over 10 miles of lateral sections.

Introduction

In the Permian Basin, extended reach lateral wells operations have been a challenge in recent decades. Maximizing reservoir contact is an optimized practice to improve oil and gas production.

Considering the construction of the extended-reach wells, issues when drilling extended-reach wells are most often related to hole cleaning, high values of torque and drag and wellbore stability, as well as difficulties in running the casing or liner to the predetermined depth. (Sabeh, et al., 2023) Those challenges offer countless opportunities to develop technologies which minimize the most common issues for ERD.

Most ERD issues are often related to the drilling fluid chosen. In many cases OBM is the leading solution for wellbore stability, hole cleaning or/and casing run issues, nevertheless, WBM can be used as an alternative. Finding the right WBM formulation used to be a significant challenge, because it had to cover the hydraulic and operational demands. The addition of an additive based on uintaite, sourced from asphaltite mines in Utah, USA, enables the combination of various mechanisms and drilling fluid functions, successfully completing an extended-reach lateral well. Details of this experience will be described in the following paragraphs.

Extended reach laterals: challenges and opportunities

Extensive lateral wells introduce opportunities to increase oil and gas production, reduce drilling costs, lower the cost per barrel of oil produced, lower environmental impact, improve reservoir drainage, and drive innovation in drilling technologies.

The opportunity to boost oil and gas production has increased the complexity of wells in the Permian Basin, introducing new challenges such as wellbore stability risks, high torque and drag, logistics, cost of drilling, completion design, and other operational constraints

Extended reach laterals in Permian Basin

US oil production demand has been an operational challenge for operators in the Permian basin.

Fig. 1 Permian Basin map (https://www.rrc.state.tx.us/)

The well-drilling business has had to keep searching for an appropriate technological solution for each operational demand. As technology has evolved toward unconventional well designs and longer lateral sections, the challenges have become greater for each of the areas involved in drilling operations.

The practice of extended lateral drilling has increased in recent decades to access the largest part of the reservoir and maximize production and operational effectiveness (see Fig. 2). The longest section drilled in the Permian Basin was 22,211’ (4.3 miles) in 2023.

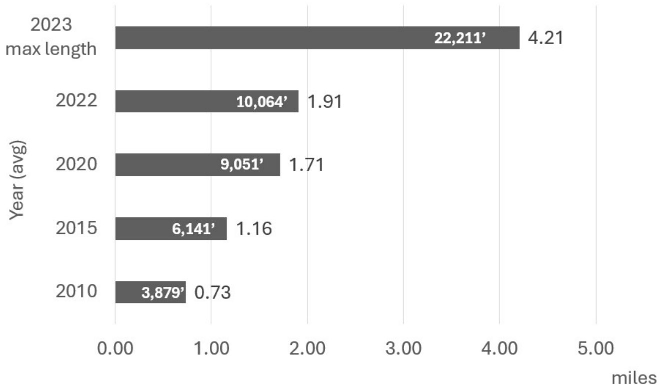

Fig. 2. Historical lateral sections length in Permian Basin (sources: Hart Energy, 2024 & Phinds, 2021)

Well design practices

During unconventional ERD well development, excessive friction must be avoided between the drill string and the wellbore. This is one of the most critical parameters to control when extended lateral sections are drilled. These frictional forces could restrict lateral length and potentially result in stuck pipe. Engineers focus on optimizing wellbore cleaning, ensuring wellbore quality, selecting the appropriate fluid system, and applying best practices to mitigate these risks.

Issues faced when drilling an extended reach well are most often related to poor hole cleaning and high torque and drag. These represent a significant challenge which is especially pronounced in the deviated and horizontal section of the well. High torque and drag values can hinder the ability to reach the desired total depth, and contribute to insufficient hole cleaning—particularly in the deviated and long horizontal sections of the well, and can burden the annulus, leading to stuck pipe and wellbore stability issues. (El Sabeh, et al., 2023). Those basic practices for ERD are the same for Permian ERD wells. To achieve the planned depth, parameters such as torque and drag, hole cleaning efficiency, and hydraulic management, the drilling fluid design should be extensively studied.

Types of drilling fluid used in ERD in Permian

The properties and design of drilling fluids are critical in facilitating the drilling of extended-reach drilling (ERD) wells to greater depths and distances. Different types of drilling fluids have been designed looking for an effective option to reduce torque and drag in these long lateral sections. Invert emulsion fluids are the most commonly used, although water-based muds such as saturated brine, cut brines, low solids systems, and HPWBM have also been used, when well conditions demand it.

Different mechanisms to measure lubricity or friction have enabled the development of new products and the combination of friction reducers could be one solution. According to Tribology theory, it indicates that three different lubrication regimes can exist between two lubricated surfaces: boundary, mixed, and hydrodynamic lubrication (Hutchings, 2017). Under this theory and study, it is considered that different sources of surfactants, ester oil, products for high salinity brines, solids and semi-solids will work depending on the regime encountered during the drilling operation.

Although no parameters directly measuring lubricity are monitored during drilling operations, there are several operational indicators reflecting the effectiveness of additives in enhancing lubricity. However, more often than not, such data is not made available to drilling fluids providers for fluid optimization. A lubricant or a fluid system is assumed to be working if the operator does not encounter major drilling problems that prevent them from reaching the target zone and length. (Zhou, et al., 2019).

Parameters such as maximizing ROP, reducing torque and drag, wellbore stability, good hole cleaning, absence of problems during tripping and casing runs, are some of the measurable indicators of how efficiently the designed water-based fluid performs.

In the Permian Basin invert emulsion has been the preferred system for years, but in some cases an alternative is required, due to the wellbore, costs, or environmental conditions. In order to achieve the best performance, solids-free brines have become widely used.

This paper describes and compares the field trial results obtained from the application of a novel additive based upon uintaite. In this case history a cut brine system based on sodium chloride was used with chlorides between 125000-150000 ppm and compared with a conventional invert OBM well.

Uintaite blend development

Uintaite is well known as the asphaltite produced in the Uinta basin in Utah, US. It possesses very unique properties as a result of its organic material deposition origin.

- Uintaite is essentially or totally of plant origin. (McGee, 1956)
- Lacustrine depositional environment belonging to Green River Formation Rock. (Andersen, 1974: Fouch, 1975)
- Immature to marginally mature within a vitrinite reflectance equivalence range of 0.4 to 0.8%. (Anders, et al, 1992).
- Kerogen type I.
- Low to no aromatic content. (NCiri et al, 2014, Helms et al, 2012))
- Low sulfur content.
- High nitrogen content.

Studies carried out by Helm et al. (2012) explain that "FT-ICR-MS indicated ~64% of calculated formula generated by ESI were aliphatic, while only about 0.8–2.5% of formula contained possible aromatic rings. All the assigned formula contained at least one heteroatom (N, O or S), indicating that ionization by ESI was selective for the polar fraction of uintaite and potentially less reflective of the overall chemical character of uintaite than NMR spectroscopy (Nuclear Magnetic Resonance). By combining the information obtained from advanced NMR and ultra high-resolution MS, Helm et al. proposed a structural model for uintaite as a mixture of many pyrrolic and a few fused aromatic rings highly substituted with and connected by mobile aliphatic chains, seen in Fig. 3. (Helm et al. 2012).

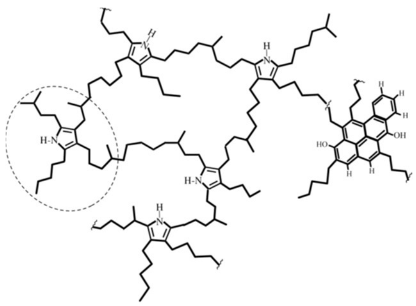

Figure 3. Model of the main components of uintaite chemical structure. (Helm et al, 2012)

Figure 4, (a) shows the 15N CP/MAS spectrum of uintaite without dipolar dephasing, while (b) shows 291µs recoupled 1H-15N dipolar dephasing, which suppresses the signals of protonated nitrogen. No significant signals were detected in the 15N CP/MAS with recoupled dipolar dephasing (b), indicating that all N forms are protonated, consistent with pyrrolic N-H groups (Helm et al, 2012).

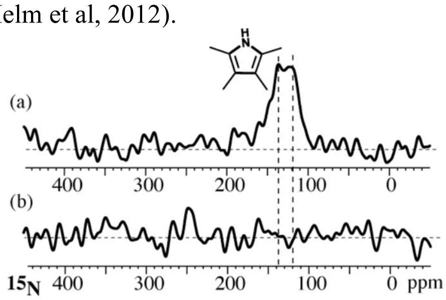

Figure 4. 15N and 13C cross polarization-magic angle spinning (CP-MAS) NMR of uintaite. (Helm et al, 2012)

Based on the analyses conducted from various sources and the historical wellbore stabilization experiences reported from operators, (Aguilar et al. 2024) the evidence clearly shows that the reaction of uintaite with shales creates an excellent chemical and physical interaction to improve wellbore stability when used in water-based fluids.

According to the studies mentioned and operational experiences collected, uintaite is characterized as an amphipathic ore. It has two parts, one is hydrophobic, and the other is hydrophilic. This behavior can be explained by the polarity of the ore, where the polar side exhibits hydrophilic properties, while the remaining organic structure is hydrophobic.

As a result of the combination of uintaite with sulfonated asphalt, an enhanced product, with the best properties of both products was created.

Due to uintaite's effectiveness in an oil-based environment and sulphonated asphalt's compatibility with both Water-Based Mud (WBM) and Oil-Based Mud (OBM) systems, it can be utilized as a transitional additive between oil and water-based systems. Moreover, the surfactant/wetting properties of sulfonated asphalts allow uintaite particles to be dispersed in WBM delivering benefits such as wellbore stability, lubricity and fluid loss control.

Case history

OBM provides important lubricity and friction reduction that enhances lateral drilling operations, but the associated handling and residual issues motivates companies to investigate water-based systems. As a result of OBM alternatives, recent efforts were implemented to trial a water-based system that were absent the typically damaging mud components (gel, barite, etc.) but instead utilized polymers & lubricants to yield the desired friction values necessary for extended reach drilling operations. The 2.5 miles lateral section in the target formation of the 2nd Bone Springs was impacted by a water influx requiring the displacement of the oil-based system for a cut brine/ lubricant system (WBM).

Initially, the cut-brine/lubricant system achieved the desired drilling parameters, but the uncontrolled fluid loss and subsequent product maintenance had a negative impact on drilling costs. After the addition of the uintaite-based blend to the system, fluid loss was now controlled, and excessive product maintenance was eliminated. In addition to the lower filtrate values, addition of the uintaite blend also improved key lubricity values and resulting drilling performance. Figure 5 shows the fluid loss trend once the uintaite blend was added to the cut brine system, starting with no control at initial depth (D0) until achieving 7-8 ml/30 min.

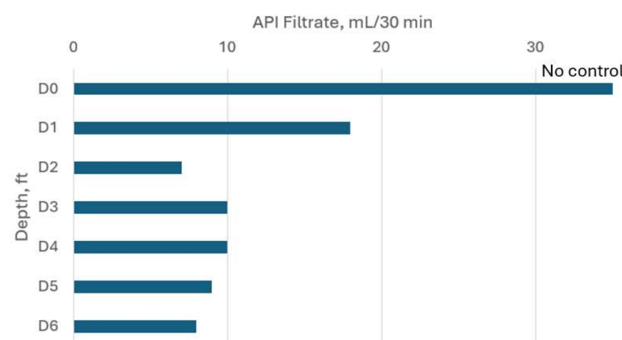

Figure 5. API fluid loss vs depth after adding the uintaite blend treatment .

Several performance indicators were recorded during the trial, and overall, there was an improvement in torque, particularly while the product was being added, that comparison is shown in Figure 6. Torque remained low, allowing the driller to maintain typical drilling parameters, all the way to TD. There was some slight rotation required getting casing to bottom starting at ~17,000’, which was expected. The ROP was higher compared with previous experience when the cut brine system was used and even compared to OBM. See figures 7 and 8.

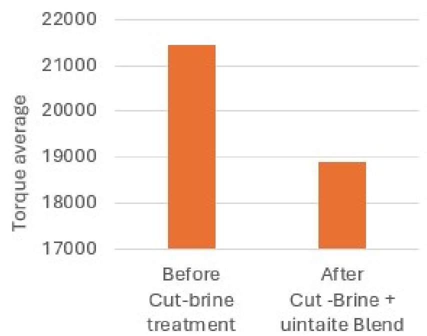

Figure 6. Torque average comparison before and after adding the uintaite blend treatment.

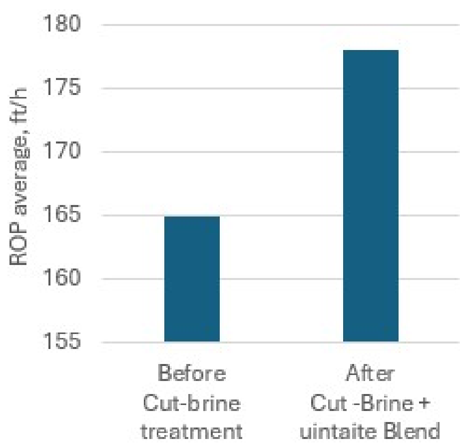

Figure 7. ROP comparison before and after adding the uintaite blend.

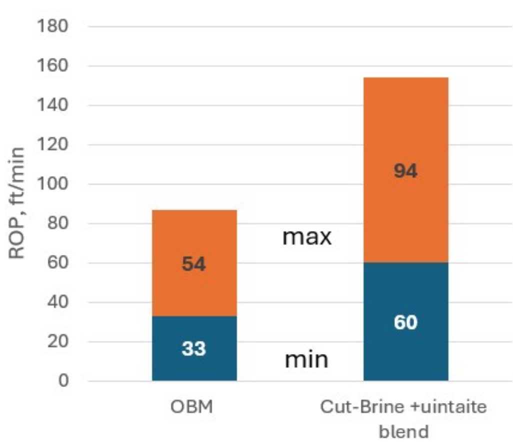

Figure 8. ROP comparison between an OBM well and a WBM well treated with the uintaite blend.

Drilling fluids for ERD wells are designed to provide a flatter rheological profile to reduce the effect of the fluid rheology on the equivalent circulating density (ECD) (Cameron, 2001). This objective was successfully met with the cut brine system treated with the uintaite blend. Figure 9 illustrates the ECD behavior during the drilling operations, comparing it with previous OBM well. Planned mud weight density for both wells were compared to the generated ECD in two parts of the wells (bit and shoe). The resulting differences between those values were graphed.

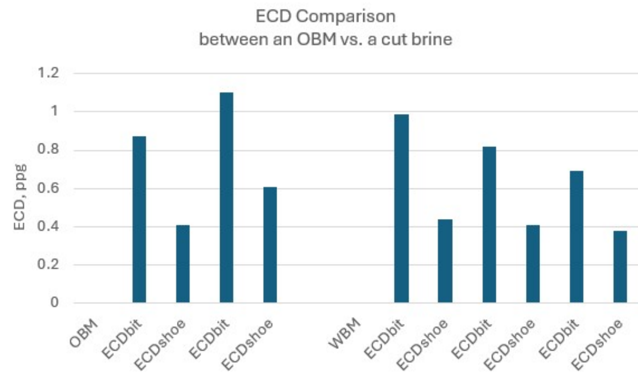

Figure 9. Differential ECD between two wells: a previous OBM compared to a cut brine+ uintaite blend.

The differential ECD values with the cut brine system consistently yielded lower ECDs compared to the OBM well. This improved performance can be attributed to the use of low solids system and the implementation of effective rheological control and hole cleaning practices.

Table 1 below illustrates the rheological properties observed in the ERD well drilled and compares them to the OBM properties from the previous well.

Operational practices together with the performance of the cut brine system treated with the uintaite blend enabled the drilling performance of the 2.5-mile lateral section to match previous OBM performance for this type of ERD well. At the time of writing this paper more than 10 miles of laterals have been drilled.

Table 1. Typical properties for a cut brine system and OBM system during the ERD section.

Properties	Cut Brine Plan	Cut Brine Actual	OBM
Density, ppg	9.4-10	9.8-10	9.4-9.6
pH	8.5-10	8.5	-
Plastic Viscosity, cP	1-8	7	10-20
Yield Point, lb/100ft2	1-10	1-7	1-8
API Filtrate, mL/30 min	no control	Initial 18 final 8	-
HPHT Filtrate, mL/30 min	-	-	14-15

Lubricants are the key component for WBM's designed for ERD. In this trial, the cut brine / lubricant formulation was enhanced as a result of the uintaite-based blend, which improved the mud system properties, providing an effective alternative for ERD lateral sections in the Permian Basin. The basic cut brine formulation is outlined in Table 2. Additional operational highlights included good wellbore stability, no changes in rheology, no issues at the shakers, a lubricious and slick filter cake, casing runs with no issues, NPT reduction, less rig cleaning, less waste disposal and lower overall cost.

Table 2. Cut brine system formulation vs actual consumption of additives

Formulation	Plan	Actual
Cut Brine NaCl brine: 9.1-9.2ppg	9.1	9.1
Lubricant	3-5%	~3-4%
Diesel	2%	~2%
Soda Ash/NaOH	pH control	8.5
Wellbore Stabilizer, ppb	-	7
Cleaning Sweeps	as required	-

Conclusions

The successful application of the uintaite-based blend in drilling a 2.5-mile extended-reach lateral (ERD) well in the Permian Basin demonstrates its viability as an alternative to oil-based mud systems. This case study highlights a breakthrough in drilling technology—successfully replacing previous systems that had issues with an innovative water-based mud (WBM) enhanced by a uintaite-based blend. By making this switch, the drilling team was able to overcome unexpected challenges, such as water influx, while maintaining efficiency and reducing costs.

The transition from OBM to WBM was effectively managed, maintaining key performance indicators such as improved fluid loss, enhanced lubricity, rate of penetration, torque reduction, wellbore stability, reduction in other needed additives, and contributed to overall cost efficiency. These benefits translated into faster drilling, fewer NPT operational setbacks, reduced washouts, and a more environmentally responsible alternative to conventional methods.

These results highlight the potential for uintaite-based additives to expand the use of WBM in challenging ERD applications, reducing environmental impact while maintaining operational performance. Further trials and usage could optimize its use in diverse drilling environments. The insights gained from this case history reinforce the need for continued innovation in drilling fluid technology to meet the evolving demands of the industry.

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Nomenclature

API = American Petroleum Institute
CP/MAS = Cross Polarization Magic Angle Spinning
DF = Drilling Fluid
ERD = Extended Reach Drilling
ESI = Electrospray Ionization
FL = Fluid Loss
FT-ICR-MS = Fourier-Transform Ion Cyclotron Resonance Mass Spectrometry
HPWBM = High Performance Water Based Mud
NMR = Nuclear Magnetic Resonance Spectroscopy
NPT = Non-Productive Time
OBM = Oil Based Mud
ppm = parts per million
ROP = Rate of Penetration
TD = Total depth
WBM = Water Based Mud

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