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Uintaite Application in Deepwater Operations

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Abstract

Uintaite, a well-known drilling fluid additive, has been used in the oil and gas industry for more than 60 years. Known globally as Gilsonite, Uintaite is a naturally occurring asphalt-like rock found exclusively in northeastern Utah, and has been proven effective as an additive in a wide range of applications. By uniquely functioning as both a malleable and solid bonding/plugging agent, Uintaite controls fluid loss and prevents lost circulation – protecting the formation from damage. It has been used extensively in onshore and offshore shelf applications around the world. However, its use is limited in most deepwater areas primarily due to the industry's widespread belief that Uintaite, and other asphaltic additives commonly referred to as "black powders", are detrimental if discharged into a marine environment. Current industry perception is that Uintaite use will lead to compliance failures, or noncompliance, with the Environmental Protection Agency's (EPA) standards. This perception, in conjunction with the lack of technical data to prove Uintaite's value in synthetic based fluids, has limited its use in deepwater drilling operations.

This paper documents Uintaite performance in laboratory analyses that show Uintaite as a safe and effective means of extending emulsion stability and increasing the temperature threshold in invert emulsion system formulations while fully complying with EPA standards for deepwater discharge.

Introduction

Uintaite is a solid hydrocarbon used mainly in drilling fluids for fluid loss control. Discovered in 1869, it is a naturally occurring, non-hazardous and non-toxic mineral formed from a complex combination of various hydrocarbons. A natural combination rich in nitrogen and beta-carotenes while low in sulfur with a (N+S)/O ratio of 2 and an H/C ratio of 1.5 make Uintaite unique [(1)].

Uintaite has been generally grouped as a form of native asphalt, but its unusual properties make it markedly different from the bitumen or asphalts which may range from liquid to definite solid form whether native or processed. Uintaite is classified mineralogically as an asphaltite. This material is deposited in roughly parallel lines running from northwest to southeast; it occurs in vertical fissures rather than in beds, pools, or lakes where the bitumen and asphalts are found [(1)].

It occurs in a pure state compared to other asphalts, has softening points ranging from 300°F to 450°F (150 º- 232 º C), and has been used in over 150 different applications. Aside from the drilling industry, its main uses are as a natural asphalt modifying agent for road paving, an additive in sand molds used by the foundry industry, a carbon black dispersing agent, and in hard resin printing for newspapers and magazines. Since the mid 1950's Uintaite has been used in the drilling industry for wellbore cementing as well as oil- and water-based drilling fluids to assist in borehole stabilization. It has been well documented that this additive can minimize borehole collapse in formations that contain water sensitive sloughing shales [(5)].

Uintaite has proven to be unique in drilling fluid applications in difficult and complex well operations, where the associated problems can result in increased drilling and completion costs as well as environmental risks associated with failures[(3)].

This paper presents a summary of performance and environmental compliance for Uintaite in deepwater drilling operations, where the prominent drilling fluids used are synthetic based. The most common fluid is the base oil IO 16-18 with specifically designed additives. A complete set of drilling fluids testing was carried out to determine Uintaite's behavior and synergies in this specific formulation. The second part of the comprehensive testing carried out consisted of evaluating Uintaite's impact (if any) on the synthetic base fluid's ability to pass stringent Gulf of Mexico environmental regulations as dictated by the Environmental Protection Agency (EPA).

Uintaite Use in Invert Emulsions

Uintaite's effectiveness in a wide variety of drilling fluid types and formulations is well documented and proven. Given its malleability [(3)], Uintaite is well known for stabilizing sloughing shales by penetrating pore spaces, micro fractures and bedding planes. However, deepwater is a particular area where this additive is not widely used and technical information is scarce. Because of this, other fluid loss control additives have been predominantly used in deepwater drilling fluid formulations.

Given the environmental requirements and challenging drilling conditions, the vast majority of operators use synthetic-based fluids. Synthetic-based fluids are non-aqueous drilling fluids used in drilling mud. These synthetic-based fluids can be composed of linear alpha olefins, internal olefins, or esters that are released into the marine environment as a residue on the discharged cuttings.

In general, Uintaite has applications for fluid loss control and shale stability as a plugging agent because of its malleable properties and bonding capabilities. It improves drilling fluid properties because of its unique characteristic as a low-density material that bonds with clays and other solids to improve wellbore stability, thus preventing differential sticking and formation damage. As a result, Uintaite has been employed in wellbore strengthening in several areas. Its “smear effect” on non-permeable formations and bonding characteristics make it highly effective at controlling lost circulation and strengthening the overall wellbore (3).

Uintaite uses a physical process to stabilize shales when added to a drilling fluid system. It penetrates the micro-fractures or pore spaces of shale as the bit penetrates the formation. It extrudes into the shale pore spaces, micro fractures, and bedding planes and forms a coat or a thin film on the borehole surface in a plastic manner. Since Uintaite is not soluble in water the penetration is not deep, resulting in the surface coating of the shale. This coating is believed to change the membrane efficiency of the rock. Sulfonated asphalts penetrate deeper into the fractures because of their solubility and do not plate as well as the insoluble products (2).

Several case histories explain the value of Uintaite in applications well above 4500psi of differential pressure in directional and horizontal wells (6).

Extensive laboratory testing was performed to determine Uintaite’s behavior in synthetic-based fluids. The tests were run using actual field mud formulated with standard synthetic fluid IO 16-18, which is the most prevalent base fluid in deepwater operations in the Gulf of Mexico and several other deepwater basins around the world. The tests were aimed to demonstrate Uintaite’s behavior in a synthetic-based mud (SBM), and its effectiveness to improve key drilling fluid properties such as rheology, fluid loss and emulsion stability. Keeping in mind that environmental compliance is paramount for any discrete drilling fluid additive, including the SBM as a whole, a complete set of environmental testing was carried out in parallel.

To perform the tests, the mud samples were hot rolled at 250°F for a period of 14 hours and a complete set of drilling fluids properties tests were carried out including electrical stability, rheological profile, and HPHT fluid loss. Subsequently the same tests were repeated after hot rolling for the same period of time (14 hrs.) but at varying temperatures, including 300°F, 325°F, and 350°F. Afterwards, the addition of Uintaite was initiated using different softening point grades. The table below summarizes the battery of tests performed:

Table 1. Tests performed

	Uintaite grade (Softening point in °F)					
		SP 350	**SP 400**	**SP 415**	**SP 430**	**SP 450**
Hot Roll Temperature (°F)	**250 °F**	0 / 6	0 / 6	0 / 6	0 / 6	0 / 6
	300 °F	0 / 6	0 / 6	0 / 6	0 / 6	0 / 6
	325 °F	0 / 6	0 / 6	0 / 6	0 / 6	0 / 6
	350 °F	0 / 6	0 / 6	0 / 6	0 / 6	0 / 6

Concentration (in ppb)

Laboratory Test Procedure

All samples were prepared and tested in accordance with API RP 13B-2: Recommended Practice for Field Testing of Oil-based Drilling Fluids. The field SBM was obtained from Gulf of Mexico wells with a density of 14 PPG. The specific Uintaite grades evaluated were 350°F, 400°F, 415°F, 430°F, and 450°F.

Sample Mixing/Aging

Laboratory Mixers controlled with Variacs were used to mix the mud components into 350mL (1-barrel equivalent) samples for testing at 250°F, 300°F, 325°F, and 350°F. Maintaining a constant vortex, 6g of Uintaite was thoroughly mixed for at least ten minutes. Each 350mL sample was loaded into an Aging Cell, pressurized with 50 (250°F), 100 (300°F), and 150 (325°F, 350°F) psi of nitrogen for aging, and placed in the Roller Oven to condition at temperature for 14 hours. After the mud sample was cooled and re-mixed, it was tested for rheology, fluid loss and electrical stability.

Rheology readings were done using OFITE Model 900 Viscometers for 600 RPM and 300 RPM at 150°F in accordance with API RP 13B-2 Section 6.3. The plastic viscosity, yield point, 10-second gel strength, and 10-minute gel strength were also calculated.

The strength of the emulsion was determined following API RP 13B-2 Section 10 at 150°F with the Electrical Stability Meter.

Fluid loss was demonstrated through high temperature high-pressure fluid (HPHT) loss at 250°F, 300°F, 325°F and 350°F. The equipment and method used was a 4-Unit HPHT Filter Press with 175mL threaded HPHT Cells in conformance with API RP 13B-2 Section 7.2. The delta pressure was maintained at 500psi throughout testing and the filtration media used was 2.5” specially hardened filter paper for filter Presses. Time was observed with a stopwatch and initial spurt and 30 minute fluid loss volumes were collected and measured in 50mL graduated cylinders.

The HPHT fluid loss results as well as the rest of the relevant drilling fluids properties are shown in tables 2, 3, 4, and 5.

Table 2. 250°F test results

RESULTS	Blank	SP 350	SP 400	SP 415	SP 430	SP 450
Plastic Viscosity (cP)	27	36	37	35	34	33
Yield Point (lbs/100ft^2)	4	13	10	10	9	17
HPHT Filtration (mL)	0.8	0.5	0.2	0.2	0.2	0.2
Electrical Stability (V)	225	290	271	285	337	340
Filter Cake (inches)	1/32	1/32	1/32	1/32	1/32	1/32

It is evident that when Uintaite was added, the results showed improvement in fluid loss properties, from 0.8ml (untreated) to 0.2ml when treated with the higher softening point grades. Rheology and ES were also positively affected in all cases.

Table 3. 300°F test results

RESULTS	Blank	SP 350	SP 400	SP 415	SP 430	SP 450
Plastic Viscosity (cP)	32	33	32	38	37	33
Yield Point (lbs/100ft^2)	4	7	11	5	7	8
HPHT Filtration (mL)	4.0	2.6	1.0	1.2	1.4	2.0
Electrical Stability (V)	278	327	347	324	340	343
Filter Cake (inches)	1/32	1/32	1/32	1/32	1/32	1/32

At this temperature the most noticeable change was the considerable increase in HPHT fluid loss when compared to the tests ran at 250ºF: a value of 4mL for the blank (untreated) sample and a 35% improvement when the 350ºF Uintaite was added. Furthermore, a fourfold improvement was observed when the 400ºF Uintaite grade was used.

Table 4. 325°F test results

RESULTS	Blank	SP 350	SP 400	SP 415	SP 430	SP 450
Plastic Viscosity (cP)	25	31	32	29	31	37
Yield Point (lbs/100ft^2)	11	15	10	14	17	5
HPHT Filtration (mL)	5.6	5.6	1.7	1.6	1.8	1.8
Electrical Stability (V)	297	360	350	313	320	304
Filter Cake (inches)	1/32	1/32	1/32	1/32	1/32	1/32

As the test temperature increased, the consistent improvements in HPHT filtration and ES were corroborated, as well as the fact that the Uintaite's softening point consistently trended with the temperature, validating the known fact that for best results the softening point window is +/- 100ºF when compared to the bottom hole temperature.

Table 5. 350°F test results

RESULTS	Blank	SP 350	SP 400	SP 415	SP 430	SP 450
Plastic Viscosity (cP)	29	34	32	41	36	37
Yield Point (lbs/100ft$^{2)}$	21	14	20	8	20	6
HPHT Filtration (mL)	43.4	42.2	19.6	4.8	6.2	6.2
Electrical Stability (V)	343	343	348	323	350	360
Filter Cake (inches)	1/32	1/32	1/32	1/32	1/32	1/32

This was the highest temperature used for the battery of tests where good results were obtained. It was observed that the HPHT fluid loss went from uncontrolled to only 4.8mL in the best performing softening point grade.

Analysis of results

As previously stated, the objective was to evaluate the effect of Uintaite samples with different softening points above 250°F on SBM from the Gulf of Mexico. The mud formulation used by an operator (IO 16-18) was reported to be effective in environments up to ~300°F. This study demonstrated the ability of Uintaite to extend the whole mud system stability at temperatures above 300°F.

HPHT Fluid Loss

As expected, the HPHT fluid loss increased with every increase in aging and temperature. The samples aged at 250°F had fluid loss in the range of 0.2-0.8mL. All of the HT additives had 0.2mL fluid loss.

At 300°F, the high temperature (HT) grades had the least amount of fluid loss (1-2mL), significantly less than the Blank (4mL). The HT 400 ore had the lowest fluid loss.

At 325°F, the HT ore had the least amount of fluid loss (1.6-1.8mL), significantly less than the Blank or 350SP ore (5.6mL).

At 350°F, the HT ore with softening point (SP) ≥415 had the least amount of fluid loss (4.8-6.2mL), significantly less than the Blank (43.4mL).

Filter cake thickness at 250°F was difficult to determine since there was not a filter cake built. Measurable filter cakes were present after ≥300°F HPHT testing and were mostly below 0.1 inches for the additives that performed well preventing fluid loss.

At 250ºF, in mud samples without Uintaite additions, the mud properties show a low yield point and 0.8mL of HPHT filtrate, as well as an ES of 225V, while at higher temperatures, the blank samples consistently underperformed.

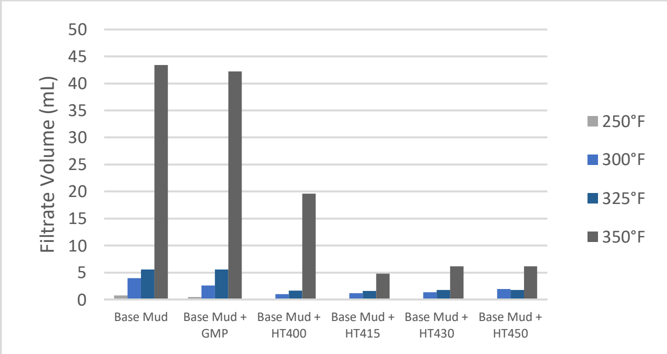

Figure 1. HPHT Fluid Loss at 500psi

Figure 1 shows the reduction of HPHT using Uintaite HT 415, 430 and 450 stabilizing the mud up to 350ºF. The control of HPHT fluid loss at 350ºF is similar to the mud performance at temperatures lower than 300ºF without treatment.

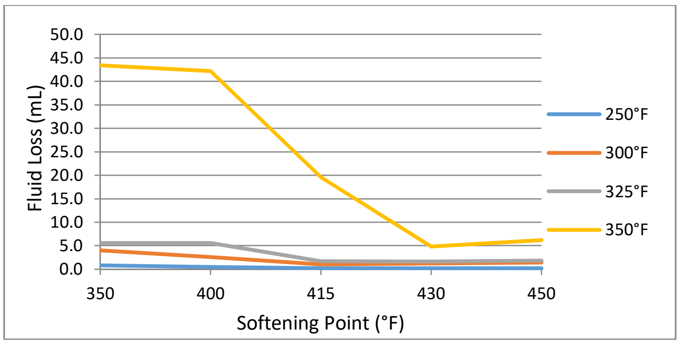

Figure 2. Uintaite Softening Point versus Fluid Loss

Figure 2 summarizes the behavior of different Uintaite grades and their direct correlation with higher test temperatures, where at a 350ºF test temperature, the most effective grades are the HT 430 and HT 450, reinforcing the importance of selecting the adequate softening point grade for the temperature in which the additive is being used.

Rheology

Rheology values were fairly similar across the range of aging temperatures given that this mud system is designed to have stable rheological properties.

The range of plastic viscosity (PV) values were similar from 250°F to 350°F (25-40cP), but values were slightly higher with the addition of Uintaite due to the addition of solids. It is important to note that no additional treatment was performed in the SBM.

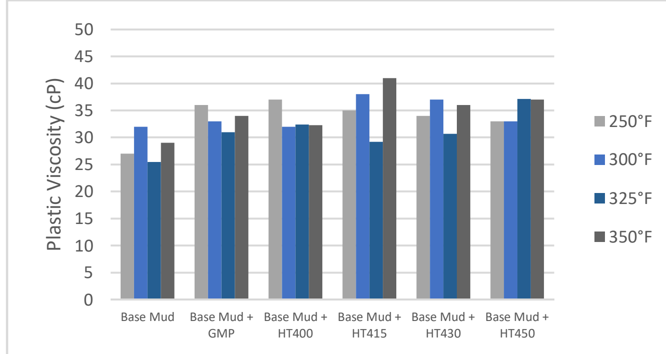

Figure 3. Plastic Viscosity at 150°F

The yield point (YP) values were similar at all temperatures and ranged from ~4-17lbs/100ft^2. Mud with no additives (Blank) typically gave PV and YP values at the low end of the ranges.

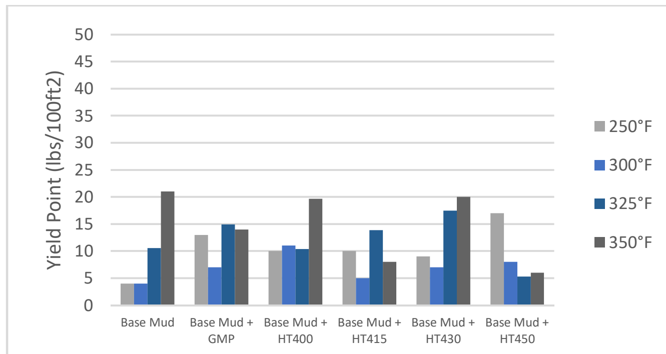

Figure 4. Yield Point at 150°F

Excluding outliers, the 10-second gel strengths ranged from 5 to 10lbs/100ft^2 and the 10-minute gel strengths ranged from 18 to 21lbs/100ft^2.

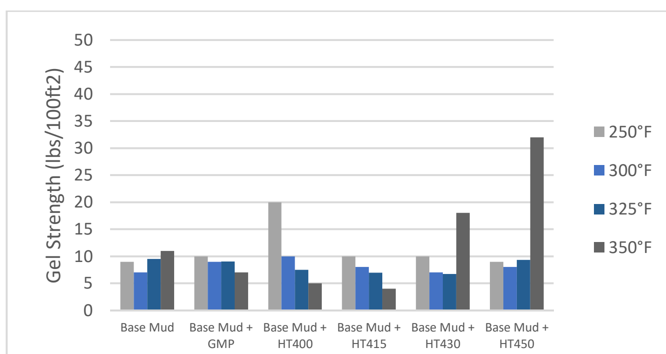

Figure 5. 10-second Gel Strength at 150°F

In general, the gel strength values decreased with aging temperature.

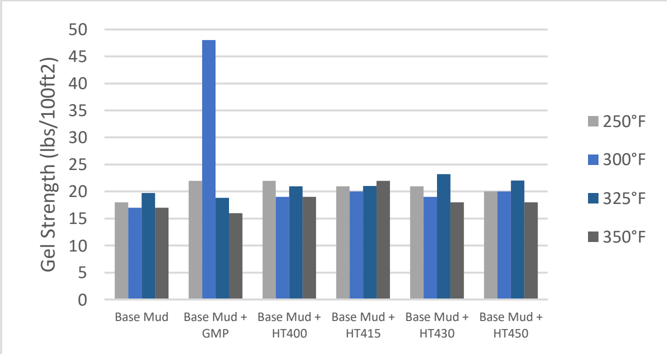

Figure 5. 10-minute Gel Strength at 150°F

The trend between 10 second gels and 10 minute gel strengths was relatively flat, with no significant exponential increases.

Electrical Stability

The electrical stability (ES) of the mud did not vary significantly with temperature. The Blank sample was lower than the samples with Uintaite, however most samples were in the ~300-350 V range.

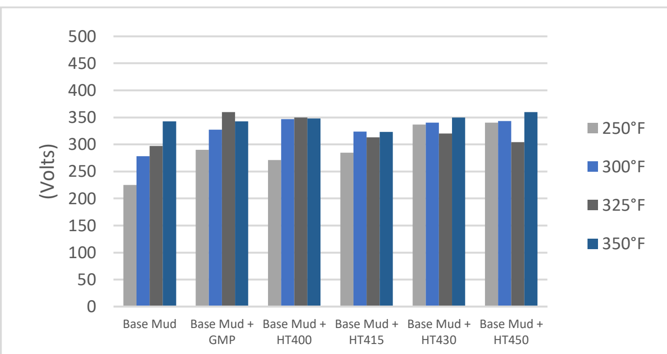

Figure 6. Electrical Stability

Environmental Performance

While Uintaite's overall performance in SBM is key to determine its value as an additive in these types of fluids, environmental compliance is the aspect that qualifies the product for its use in SBM and deepwater environments. Therefore, in parallel to the traditional drilling fluid properties testing, a complete and exhaustive set of environmental tests were carried out to determine Uintaite's potential effects in SBM used in the Gulf of Mexico.

The tests were performed in a certified third party laboratory, following EPA guidelines EPA-821-B-00-013 [8]. In order to obtain conclusive environmental results, Methods 8310 and 3630C that reference PAH content were also carried out.

All environmental tests were carried out using field mud from the Gulf of Mexico, with 3ppb and 6ppb Uintaite concentrations as well as without Uintaite additions (witness). These include Static sheen, 96 hours LC 50 Aquatic Bioassay, Reverse Phase Extraction test (RPE), Gas Chromatography Mass Spectrometry (GCMS), Sediment Toxicity (SedTox), and PAH content.

EPA Static Sheen Test

This test is intended to indicate presence of free oil when drilling fluid, drilled cuttings, deck drainage, well treatment fluids, completion and workover fluids, produced water or sand, or excess cement slurry are discharged into offshore waters. Two types of sheen tests are mandated by EPA under NPDES permits. The visual sheen test consists of an observation made when surface and atmospheric conditions permit watching the ocean water for a sheen around the point where the discharge entered the water. When the conditions do not permit visual observations, a static sheen test is mandated by NPDES permits and the protocol published by US regulators. This test uses seawater in a shallow pan not more than 30cm deep with 1000cm^2 surface area. Either 15cm^3 of fresh mud or 15g fresh cuttings are injected below the surface of the water. An observer watches for up to 1.0 hour for a silvery, metallic, colored or iridescent sheen. If sheen covers 50% of the area, the mud or cuttings cannot be discharged. [8]

96 hours LC 50 Aquatic Bioassay

Aquatic toxicity is measured by fish bioassay. A waste can be tested for this criterion by placing some waste in a test water tank and introducing Mysid shrimp.
Aquatic Toxicity waste is hazardous by aquatic toxicity if a 96-hour LC_{50} is less than 500mg/liter.

96-hour LC_{50} < 500mg/l = acute aquatic toxicity.

EPA specifies the use of the 96-hour test duration for point-of-discharge monitoring in order to allow operators to continue drilling operations while the sediment toxicity test is being conducted on the discharge drilling fluid.

SPP = Suspended Particulate Phase of 1 part mud to 9 parts seawater mixture.

Compliance target is an LC50 ≧ 30,000ppm SPP**.**

Reverse Phase Extraction (RPE) test results

The test is essentially examining the mud under a UV light to look for fluorescence. Several comparisons are made with the following blank fluids to ensure proper evaluation:

- IPA (Isopropyl Alcohol), IPA Blank Always passes.
- NAF (Non-Aqueous Fluid), NAF Blank Always passes.
- NIST oil, standard oil used as a control in the test, always fails.

The drilling fluid is tested by duplication with and without NIST oil to evaluate the presence of oil substances.

Gas Chromatography Mass Spectrometry (GCMS)

GCMS is an analytical method that combines the features of gas chromatography and mass spectrometry to identify oil substances within a test sample for environmental analysis.

Sediment Toxicity (SedTox) test

This test is used to measure the effect of the SBM coated cuttings on the sea floor. It uses *Leptocheirus plumulosus*, a common shrimp species in aquatic environments, as the test organism. The test consists of exposing the Leptos to a mixture of SBM and a formulated (man-made) sediment.

The compliance limit for an STR is ≦ 1.0

LC50 Value for the reference drilling fluid divided by the LC50 Value for the Submitted SBM sample equals the STR (SedTox Ratio).

Polycyclic Aromatic Hydrocarbons test

Polycyclic aromatic hydrocarbons (PAH) are organic compounds containing only carbon and hydrogen that are composed of multiple aromatic rings, which tend to get easily released to the environment and thus considered as contaminants.

To determine the presence of PAH in Uintaite a third party EPA-approved lab carried out tests using five Uintaite SBM samples, the same were analyzed according to EPA Methods 8310 and 3630C. A certified standard PAH mixture was used for quantification. The test results and conclusions showed that no PAH compounds were detected at levels of 6ppm or higher based on the lowest detectable levels of the method used for quantifying fluoranthene; the EPA regulations require a maximum PAH content of 10ppm in the whole SBM(8).

In addition, chemical characterization performed by the Petroleum and Environmental Institute of South Korea (7) on Uintaite showed that the amount of aromatics in Uintaite is 0%. Iatroscan data showed that Uintaite contains considerable amount of asphaltenes (79.7 wt. %) and nil amount of aromatics (0.0 wt. %). Supplementing this information the characterization shows that Uintaite seems devoid of any aromatic at all. The considered material exhibits no pronounced aromatics peak in the chromatogram; it must be pointed out that the Uintaite is indeed largely nonaromatic. Always as per the Petroleum and Environmental Institute, its use is likely to have important health and environmental advantages over the use of petroleum pitches, which characteristically have a high content of polynuclear aromatic hydrocarbons (7).

Table 6. Gulf of Mexico Discharge Requirements for SBM

EPA test	Requirement to Pass	SBM Used in GoM	SBM + 3 ppb of Uintaite	SBM + 6 ppb of Uintaite
Static Sheen	No sheen	Pass	Pass	Pass
LC-50 Aquatic Bioassay	> 30,000ppm SPP	929,380	933,350	890,670
RPE	No Fluorescence	Pass	Pass	Pass
GCMS	Crude oil < 1%	0.06	0.06	0.06
STR	< 1.0	0.3	0.25	0.22

Conclusions

- From 250°F to 325°F, all of the SBM with Uintaite samples significantly decreased fluid loss. Thus, Uintaite HT ore with an SP of 400-450°F can extend the working range of a SBM to 325°F.
- At 350°F, ore with SP temperatures ≥415°F decreased fluid loss at least 7-fold compared to the base mud, extending the working range of the mud to 350°F.
- Uintaite did not have a significant effect on rheology, but the general trend indicates that it increases most rheology values slightly; further treatment with wetting agents are recommended to maintain rheological values.
- Uintaite reduces HPHT fluid loss significantly.
- Uintaite with SP of 415, 430, and 450 showed the best overall performance.
- SBM with Uintaite content passed Static Sheen, LC-50 Aquatic Bioassay, RPE, GCMS, SedTox, and PAH tests required for deepwater use.
- Uintaite is a safe and effective means of extending emulsion stability and increasing the temperature threshold in SBM while fully complying with EPA standards for deepwater discharge.

Acknowledgments

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Nomenclature

EPA= Environmental Protection Agency in the United States
ES = Electrical Stability
GCMS = Gas Chromatography Mass Spectrometry
GM-P = Uintaite >350°F SP grade
HPHT = High Pressure, High Temperature
HT = High Temperature
HT 400 = Uintaite >400°F SP grade
HT 415 = Uintaite >415°F SP grade
HT 430 = Uintaite >430°F SP grade

HT 450 = Uintaite >450℉ SP grade
IPA = Isopropyl Alcohol
LC-50 = Lethal Concentration required to kill 50% of the population
NAF = Non-Aqueous Fluid
NIST = National Institute of Standards& Technology Oil
NPDES = National Pollutant Discharge Elimination System
PAH = Polycyclic Aromatic Hydrocarbon
PV = Plastic Viscosity
RPE = Reverse Phase Extraction
SBM = Synthetic Base Mud
SedTox = Sediment Toxicity
SP = Softening Point
SPP = Suspended Particulate Phase
STR = SedTox Ratio
YP = Yield Point

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