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Temperature-Dependent Rheological Response of Organophilic Clay for High-Temperature Drilling Operations

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Abstract
During drilling geological formations, several challenges arise from in-situ formation of pressure and temperature. The rheological properties of the mud must be carefully and regularly monitored to ensure that drilled cuttings continue to move to the surface efficiently by improving low-end rheology, averting barite sag. In this paper, oil-based muds (OBMs) with the same composition were prepared, while two industrial organophilic clay products were blended into each mud sample, designated as samples A and B. The properties of both mud samples were evaluated at room temperature, while the rheological response of the two OBM samples was monitored over a temperature range of 80 to 160°F. The results showed that temperature had no significant influence on mud weight, marsh funnel viscosity, alkalinity, or chloride. However, plastic viscosity constantly decreased from 70 cP at 80°F to 30 cP at 160°F, while yield point (YP) gradually increased from 20 lb/100 ft² at 80°F to 23 lb/100 ft² at 160°F. Both samples A and B decreased in the flow behaviour index (n) from 0.83 at 80 °F to 0.66 and 0.70, respectively, at 160 °F. On the other hand, the consistency index (K) for samples A and B steadily increased from 0.5 at 80 °F to about 0.96 and 0.95, respectively, at 160°F, as both mud samples were subjected to increasing temperatures under shearing conditions. While both clay samples proved excellent for cuttings movement, it is important to carefully manage their concentration to prevent the yield point from exceeding the desired limit, as a further increase in YP may hinder the landing of casing pipes at the bottom of the hole due to the fluid's buoyancy. Both clay samples exhibited similar low-end R80° geological performance, which is necessary to prevent drilled cuttings from settling in the cuttings at 160°F to avert stuck-pipe problems.

Keywords: ***Oil-based drill mud, Temperature effect, Flow behavior index, Consistency index***

1.0 Introduction

Drilling fluid serves as a lifeline during drilling operations through a sophisticated blend of chemical and physical elements. Carefully balanced and tailored to specific drilling conditions, these elements influence rheological properties, density, lubricating capabilities, and other crucial characteristics that impact drilling efficiency (Gaurina-Međimurec *et al*., 2021). The general composition of drilling mud is a complex amalgamation of constituents, each playing a specific role in achieving the desired rheological and functional properties. Water forms the fundamental base, serving as the primary medium for suspending other components. Bentonite, a clay mineral, frequently features prominently as a viscosifier, imparting viscosity to the drilling mud and enhancing its ability to carry drilled cuttings to the surface (Caenn *et al*., 2011). As drilling activities penetrate different geological layers with varying rock formations, pressures, and temperatures, the carefully designed properties of drilling fluid become increasingly important. It serves as a stabilizing agent that supports the wellbore, prevents collapse, and maintains the integrity of the drilled hole, which is essential for the successful execution of subsequent exploration and production operations (Apaleke *et al*., 2012). Organophilic clays (OCs) are produced by treating natural clay minerals with organic ammonium salts to alter their surface properties. They are extensively used as rheology modifiers in industrial applications, including greases, cosmetics, and oil-based muds (OBM).

In drilling operations, organophilic clays serve as essential additives that enhance the performance and stability of drilling fluids **(**De Paiva *et al*., 2008**).** Studies consistently show that organophilic clay blends improve OBDF performance by increasing ultra-low shear rate viscosity (ULSRV), improving cuttings-carrying capacity, and reducing high shear rate viscosity (HSRV) (Zhuang *et al.*, 2018; Mainye & Teutsch, 2016). Blends of modified organophilic attapulgite/sepiolite and organo-bentonite clays increased ULSRV, lowered HSRV, and produced stable, non-progressive gel structures that improved cuttings transport and reduced pump pressure requirements, particularly in deviated wells (Mainye & Teutsch, 2016). Similarly, combining organo-montmorillonite (OMMT) and organophilic sepiolite (OSEP) produced superior rheological performance and greater thermal stability than either clay used individually, owing to a mixed network structure in which exfoliated OMMT nanolayers interacted with OSEP nanofibers to form a strong three-dimensional framework (Zhuang *et al*., 2018).

Experimental evaluation of organo-bentonite surface-modified with hexadecyl trimethylammonium bromide (CTABr) in the presence of soybean oil, lauryl alcohol triethoxylate, brine, CTABr-modified bentonite, and barite showed that temperature had the greatest influence on rheological behavior. Increased adsorption of quaternary ammonium cations onto the clay surface reduced the contact angle, indicating enhanced organophilicity and a stronger affinity of the modified clay for the oil phase (Ratkievicius *et al*., 2017). In addition, small quantities of organophilic clay improve the stability of OBM made with gasoil, while increasing clay concentration enhances yield stress, high-shear viscosity, viscoelasticity, and thixotropic behavior (Bergane *et al*., 2020). Overall, these studies show that organoclays improve drilling-fluid rheology, thermal stability, and cuttings transport across varying wellbore conditions, as recommended by Mahmoud *et al*. (2023). Hence, this study is aimed at investigating the rheological response of organophilic clay for high-temperature drilling operations.

2.0 Materials and Methods

The materials required to prepare the various mud samples are Base oil (AGO), Organiphilic clays (sample A and sample B), Calcium chloride, Emulsifier, Water, Soltex, Calcium carbonate, and Barite. The piece of equipment, set of apparatus and reagents used to conduct the tests are Rheometer with heating jacket, 0.282N Silver Nitrate, Phenolphtalein indicator, Potassium chromate indicator, 0.1N sulphuric acid, Isopropyl Alcohol (IPA) & Xylene (IPA/Xylene), 5ml syringe, Distilled water, 10ml pipette, 5ml pipette, Mud balance, Marsh funnel viscometer, Magnetic stirrer, Erlenmeyer flask, 100ml and 50ml measuring cylinders.

2.1 Preparation of OBM samples

The mud samples were prepared by initially preparing 5.5mg/l calcium chloride brine. The brine was prepared twice by measuring 2.75 g into 500ml of tap water, this is to ensure that each volume does not spill over the mixer cup in a Hamilton beach mixer. The prepared 1000ml $CaCl_2$ brine was kept in a sample container. Also, 600ml of base oil was transferred into a mixer cup and the following chemical additives were added slowly and orderly into base oil already in the mixer cup under constant agitation; emulsifier, lime hydrated, calcium chloride brine, clay, soltex, calcium carbonate and barite. Two OBM samples (sample A and sample B) were formulated with different organophilic clays, OBM sample A contains organophilic clay A while OBM sample B contains organophilic clay B.

The formulation of the mud samples and mud tests was conducted across both samples in order to ascertain how both clay products affect mud rheology and other vital OBM parameters.

The chemical spread and quantity of each chemical additive used in preparing the mud sample is same, the difference between both samples is the clay type used. The additives utilized in making the OBM sample include base oil (70 ml), water (30 ml), $CaCl_2$ (16 g), lime (12 g), emulsifier (5 ml), soltex (8 g), and barite (17 g).

Sample A: OBM sample + 10g of clay A
Sample B: OBM sample + 10g of clay B
Based on the philosophy of this work, essential properties of oil-based muds were tested at ambient temperature after preparation and shearing of the components together, but the response of the rheological properties at varying temperature was carefully monitored in order to achieve the intention of this work.

2.2 Rheological property test
Each of the sample to be tested was carefully transferred into the sample cup carefully placed in a heating jacket of the rheometer. The sample was stirred at 600-rpm while being heated until it reaches a temperature of 120 °F. But if the sample temperature is eventually heated above 120 °F, it must be cooled down to 120 °F. The knob containing a 600-rpm dial speed is selected, the dial reading has stabilized at this speed and the measurement is recorded, and the readings are subsequently taken at 300, 200, 100, 6, and 3-rpm. After obtaining the 3-rpm reading, the sample is agitated at 600-rpm for 2 minutes before measuring the 10-second gel strength at 3-rpm. The sample is then stirred again at 600-rpm for 2 minutes and allowed to remain undisturbed for 10 minutes while maintaining the temperature at 120 °F. The 10-minute gel strength is determined at 3-rpm. This was also repeated for 30 minutes gel strength.

2.2.1 Marsh funnel viscosity
This equipment containing an orifice is covered with a finger and a freshly agitated fluid sample through poured through the screen into a clean, dry, upright funnel until the fluid level reaches the bottom of the screen. Immediately remove the finger and record the time required for the fluid to flow into the receiving vessel up to the one-quart (946 ml) mark. The funnel viscosity measurement is intended only as an indicator of relative changes in drilling fluid properties and should not be directly correlated with viscosity values obtained from rotational viscometers. The funnel should be calibrated regularly to ensure accurate measurements. The viscosity of fresh water at 70 °F should be approximately 26 seconds per quart; any reading above this value indicates that the funnel spout may require cleaning. The spout has a diameter of 3/16 inch, and a hand-held drill bit of the same diameter should be used to remove any accumulated deposits or dried material.

2.2.2 Mud weight
The instrument base should be positioned on a flat, level surface. Measure and record the temperature of the mud sample. Fill the mud cup with the sample to be tested, then gently tap the cup to release any entrapped air or gas bubbles. Secure the cap by rotating it until it is firmly fitted, ensuring that excess mud is expelled through the hole at the top to eliminate any trapped gas. While holding the cap firmly and covering the cap opening with a thumb, clean the exterior of the cup by wiping it until it is dry and free of mud. Place the beam on the base support and balance it by adjusting the rider along the graduated scale. The instrument is properly balanced when the bubble aligns directly beneath the center line.

2.2.3 Alkalinity
Add 50 ml of Xylene/IPA solution into an Erlenmeyer flask. Using a 5-ml syringe, collect the whole mud sample up to slightly above the 3-ml mark. Dispense 1 ml of the oil-based mud into the solvent, then add 100 ml of distilled water. Introduce 5 drops of phenolphthalein indicator and mix thoroughly using a magnetic stirrer. While continuously stirring, slowly titrate the mixture with 0.1 N H_2SO_4 until the pink coloration just disappears. Continue stirring and observe the solution; if the pink color does not reappear within one minute, stop stirring. If necessary, allow the mixture to separate into two distinct phases to improve visibility of the color change in the aqueous phase.

2.2.4 Total chlorides

The chloride titration procedure follows the alkalinity measurement. Using the same sample previously analyzed for alkalinity, add 10–15 drops of potassium chromate indicator. While continuously stirring, titrate the sample with 0.282N and $AgNO_3$ solution until the first color change is observed. This point represents the endpoint. Do not continue titration until a brick-red color appears.

3.0 Results and Discussion

3.1 Fuid behavior index (n), consistency index (K), and alkalinity

The results obtained from the tests conducted are thus presented and were used in dignifying the performance of OBM samples in terms of rheology and other vital OBM parameters. The rheological properties of oil-based muds, including plastic viscosity, yield point, and gel strength, are controlled by solids concentration and electrochemical interactions within the fluid. These properties influence solids behavior, including buildup, flocculation, and deflocculation. Maintaining these parameters within standard specifications is essential for efficient drilling operations, as they ensure proper pressure control, lowers barite sag, enhances drilled cuttings transport, and suspension of solids (Onojake, and Chikwe, 2019). From the rheology results presented, the alkalinity also played a significant role in the rheology of the mud in terms of fluid behaviour index (n) and consistency index (K) of the mud.

Figure 1 is a plot showing the changes in the flow behavior index (n) and the consistency index (K) of the drill mud over a temperature range of 80 to 160 ^{O}C. This is an important parameter of the drill mud as it determines the ability of a drilling fluid to efficiently transport drilled cuttings from the well to the surface is based on lower "n" and higher "K" as supported by the values of the mud alkalinity in this work (API, 2021). From the results, there is a decrease in the flow behavior index (n) from about 0.83 at 80 ^{O}F to 0.66 at 160 ^{O}F. Based on power law model, as "n" is lesser than 1, the fluid exercise shear thinning indicating excellent wellbore cleaning (Bourgoyne *et al*., 1986). The alkalinity of both mud samples reflected a clear indication of rheological (shear thinning) control of the mud samples resulting in decreased viscosity, and at a low shear rate would improve drilled particle suspension. Also, the drop in temperature indicates thermal modification of the drill mud (Caenn *et al*., 2017).

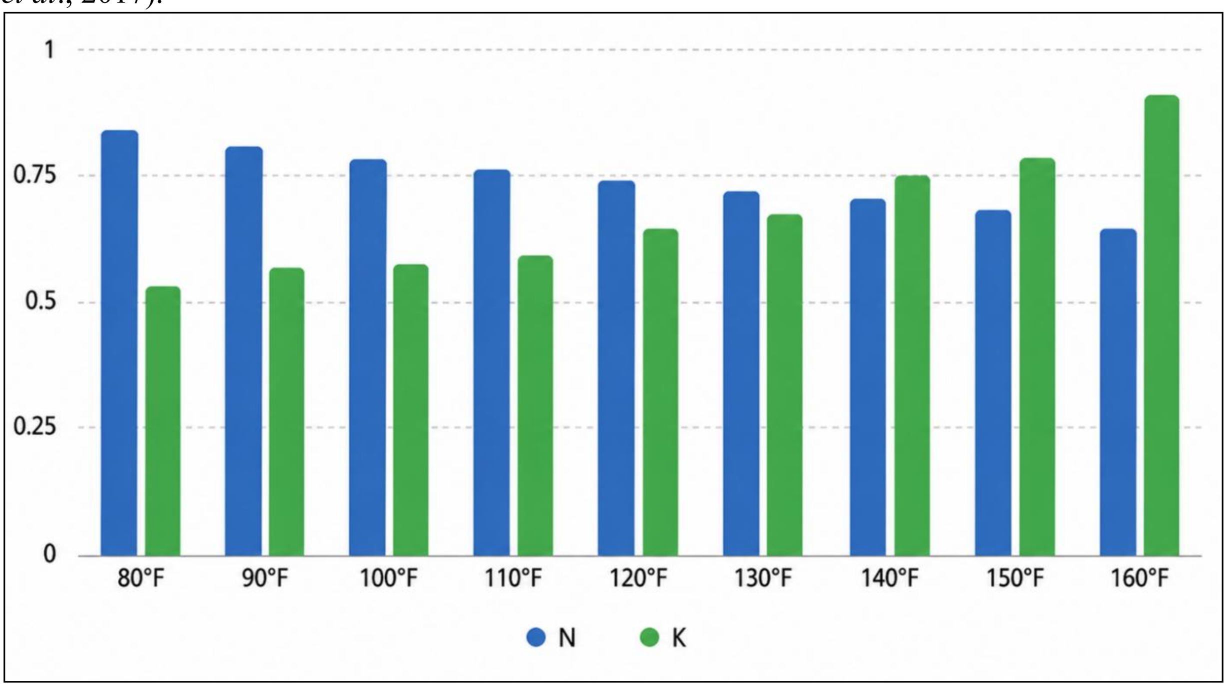

Figure 1. Changes in the flow behavior index (n) and consistency index (K) in sample A.

On the other hand, the consistency index (K) from the result steadily increased from 0.5 at 80 ^{O}F to about 0.96 at 160 ^{O}F. K at higher values indicate a higher resistance to deformation at reduced shear conditions which would improve the suspending capacity of the mud (API, 2021). However, it must also be noted that excessively high K values may increase the risk of surge, lost circulation and pressure (Darley & Gray, 1988).

Figure 1 and Figure 2 display similar rheological trends at increasing temperatures. In comparing the fluid behavior index (n), Figure 1 and 2 shows a constant decrease from 0.82-0.83 at 80 ^{O}F to less than 0.70 at 160 ^{O}F which suggests that the fluid at the recorded temperatures remained pseudoplastic (Bourgoyne et al., 1986). Nonetheless, Figure 1 shows a sharper decline in n than in Figure 2. Between temperature ranges 120 – 150 ^{O}F, n is noticeably higher that in Figure 2. This shows that the drill mud has a higher shear thinning behavior which also suggest that Figure 2 is more reactive to temperature effects. At lower n values, the fluid viscosity declines rapidly with increase shear rate, hence, reducing pressure losses and improving hydraulic efficiency. This is generally beneficial for maintaining sufficient hole cleaning during circulation (Darley & Gray, 1988).

From the results, it is shown that K continuously increased for both samples, suggesting that the drill mud has become increasingly resistant to flow at low shear conditions and at increased temperatures. At 120 ^{O}F, K increased rapidly near 0.95 at 160 ^{O}F for Figure 2, whereas, in Figure 1, K reaches about 0.84. Increased K reflects greater hydration, enhanced clay formation (Caenn *et al*., 2017). In contrast to Figure 1, Figure 2 indicates a more gradual increase in K, suggesting a more enhanced viscosity with increased temperature. Hence, Figure 2 may provide a better rheological stability, lower hydraulic resistance, and improve pumpability over the temperature range investigated. Therefore, whereas Figure 1 presents drill mud with greater structure and shear thinning behavior at increased temperature, Figure 2 presents a more thermally stable drill mud (Amanullah *et al*., 2005).

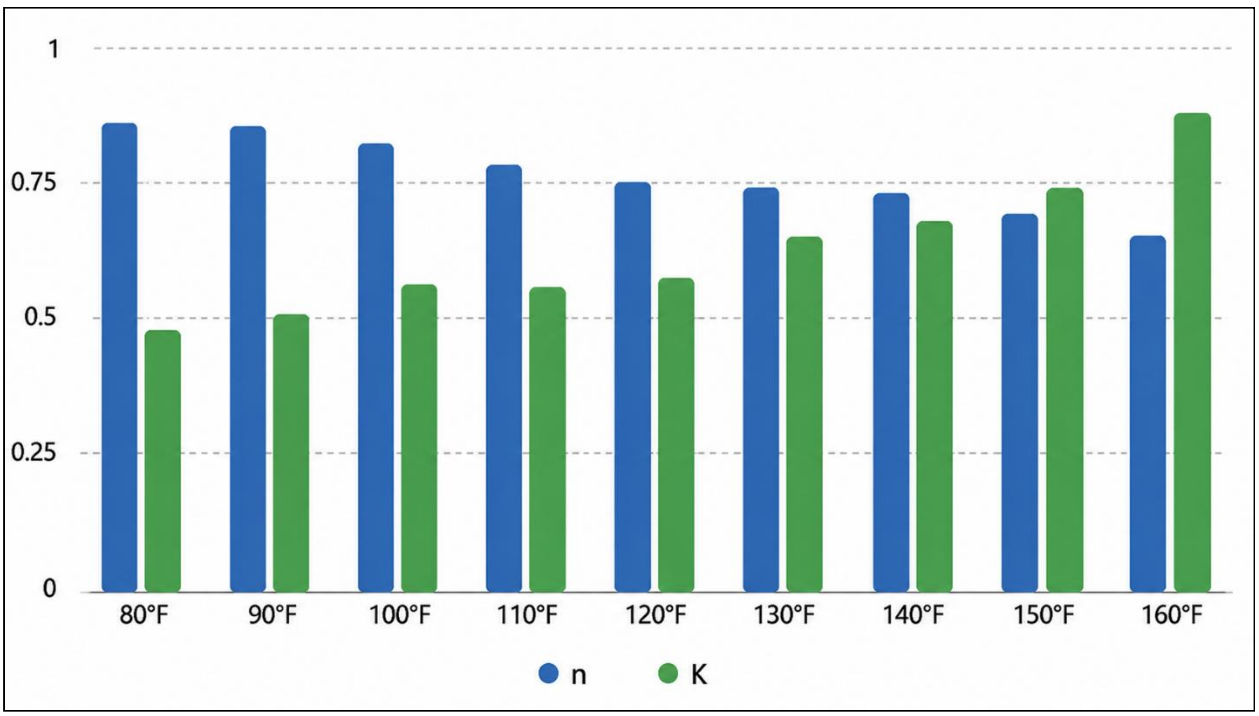

Figure 2. Changes in the flow behavior index (n) and consistency index (K) in sample B.

3.2 Plastic viscosity (PV) and Yield point (YP)

Figure 3 shows the effect of increasing temperature over a range on plastic viscosity (PV) and Yield point (YP) of the drill mud. These properties of drilling fluid are key to drilling performance in terms of mechanical attraction of components of the mud additives and the ability of the mud to transport drilled cuttings from the bottom of the well to the surface. From the Figure (3), PV decreases constantly from about 70 cP at 80 ^{O}F to about 30 cP at 160 ^{O}F. This represents a decrease of about 57%, suggesting that at increased temperature, there is a low internal resistance to flow of the drill mud (API, 2017). This increase may be due to low interparticle friction or low base-fluid viscosity (Darley & Gray, 1988). As the temperature increases with the mud under shearing condition, the plastic viscosity of the OBMs made from both clays begin to reduce gradually.

The rheological behavior of the diesel-based oil-based mud (OBM) showed a similar trend to the synthetic oil-based mud reported by Onuh et al. (2020), where increasing temperature resulted in a reduction in plastic viscosity and yield point values. Oil-based mud (OBM) is a drilling fluid system in which the continuous phase is primarily composed of oil, such as diesel, mineral oil, or synthetic oil. With increasing temperature, the kinetic energy of oil molecules increases, leading to enhanced molecular mobility and weakened intermolecular attractive forces. Consequently, the viscosity of the continuous oil phase decreases. Since plastic viscosity (PV) is strongly dependent on the viscosity of the continuous phase and the concentration of dispersed solids, the reduction in base oil viscosity at elevated temperatures results in a corresponding decrease in PV (Fink, 2021). In addition, higher temperatures reduce the viscosity of the oil phase surrounding the solid particles, producing a thinner lubricating layer. This promotes easier particle movement and decreases the resistance caused by particle–particle interactions and particle–fluid friction. Therefore, the combined effects of reduced continuous-phase viscosity and improved particle mobility contribute to the decline in plastic viscosity with increasing temperature (Caenn & Gray, 2017).

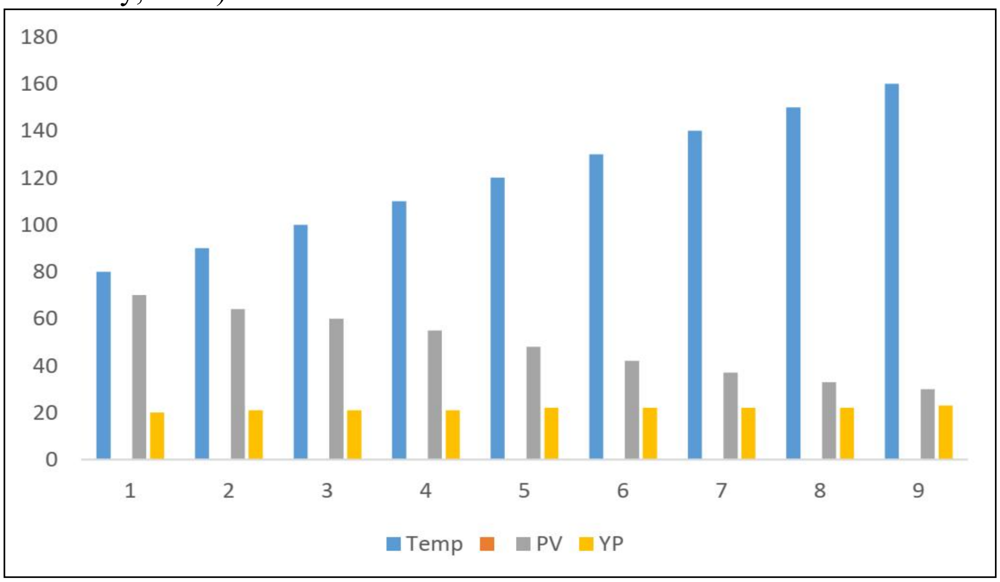

Figure 3. Effect of temperature on plastic viscosity (PV) and Yield point (YP)

In contrast to PV, YP increase gradually from about 20 Ib/100 ft^2 at 80 ^{O}F to about 23 Ib/100 ft^2 at 160 ^{O}F. The increase in YP suggest that temperature promotes a stronger particle interaction even though the overall viscosity is reduced. This may be due to improved hydration of particles and particle interaction (Riley & Fink, 2016; Caenn *et al*., 2017). At lower PV and slightly increased YP, hydraulic performance and suspension is improved while cuttings transport is preserved. This suggests that the drilling mud possesses thermal stability and maintains its rheological properties over the temperature range investigated.

3.3 Physicochemical properties

This parameter is vital to all mud types when the drilling circulation is halted. The outcome of gel helps to affirm if the mud is progressive or flat. From the results, both mud types exhibited flat gels since the differences between 10 seconds, 10 minutes and 30 minutes gels are closer. Also, is also observed that as temperature of the muds increase, the muds' gels tend to improve with all gels values tends to be getting closer. This implies that if the mud pumps are stopped for a longer time, the mud still have the capacity to suspend solids being a vital function of all mud types.

From the results presented, both clay samples exhibited similar performance in yield point at low shear rate. Both clay materials were found to steadily improve LSRYP necessary for drilled cuttings transport necessary to move cuttings at low side of cuttings in deviated or directional well. This sustenance at higher temperature prevents stuck pipe especially when drilled cuttings continue to be carried through the annulus to the surface.

From the results presented in table 1, the mud weight of both mud samples is the same at 9.8 ppg. This is due to the weight of the weighing additive (barite) used in preparing the mud samples. It is worth noting that an oil-based mud density of 9.8 ppg is relatively low which may be ideal for a formation that requires moderate hydrostatic pressure while minimizing damage to the formation (API, 2021; Bourgoyne et al., 1988). The result also reveals that the clay used is not a weighing agent. Hence, while drilling, clay is not a good choice additive when hydrostatic pressure is necessary to be maintained (Li *et al*., 2025).

The marsh funnel viscosity, mud sample prepared with clay B revealed higher marsh funnel viscosity of 81 s/quart to sample A value of 76 s/quart. Hence, a 6.6% increase in sample B suggest a stronger internal structure than sample A. This implies that a lesser quantity of clay B will be required when preparing a high viscosity mud. This increase can be attributed to the formation of a stronger three-dimensional gel structure caused by interactions between clay particles and the continuous phase, resulting in increased resistance to flow (Caenn *et al*., 2017). The higher viscosity mud is necessary in supporting weighing agents such as barite and other additives by keeping these additives in suspension.

The alkalinity of both OBM samples exhibited similar variation at 3.1 and 3.0 mL for samples A and B respectively. The minimal difference between both samples suggest that alkalinity is not likely to cause any significant change in low shear rate yield point (LSRYP). However, since alkalinity of mud supports the stability of emulsion mud system, sample A OBM can be inferred to be more stable and its water phase, definitely more emulsified with the oil phase.

The total chlorides of both mud samples were 54,000mg/l for sample A and 53,000mg/l sample B being the ability of the mud sample to inhibit shale and clay formations. Because the difference in the concentration of chloride in both mud samples is insignificant, there is unlikely to be any significant difference in on LSRYP. Consequently, the OBM with the higher chloride at the same oil-water ratio will contain more water phase salinity for describing true inhibition capacity of the mud (Amanullah & Al-Arfaj, 2011).

In all, the prepared oil-based muds, samples A and B exhibit similar properties indicating similar specifications. Nonetheless, the difference lies in the slightly higher marsh funnel viscosity and alkalinity of sample B which is expected to yield a higher LSRYP. Hence, sample B will offer a better hole-cleaning capacity during static or low circulation conditions with reference to sample A.

Table 1. Mud properties for sample A and B

Mud sample	Mud Weight (ppg)	Marsh funnel viscosity (s/quart)	Alkalinity (ml)	Excess Lime (pounds per barrel) ppb	Chloride (mg/l)
A	9.8	76	3.1	3.9	54,000
B	9.8	81	3.0	4.0	53,000

4. Conclusion

The performances of two grades of industrial clay with respect to temperature variation in OBM was studied in this work. The study shows that both clay samples exhibited similar rheological properties in terms of “K” and “n”, however, sample A exhibited better hole cleaning properties. Both clay samples support and maintain low end rheology responsible for minimizing drilled cuttings settling at bed side of a deviated hole at an increased temperature. Yield point of the mud samples tend to increase gradually while plastic viscosity lowers gradually as temperature increases. Organophilic clays at ambient temperature have no influence on mud properties such as mud weight, marsh funnel viscosity, alkalinity, chloride, alkalinity and lime content for both samples.

Declaration of interest

The author declares that there is not conflict of interest.

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References

Amanullah, M., & Yu, L. (2005). Environment-friendly fluid loss additives to protect the marine environment from the detrimental effect of water-based drilling fluids. *Journal of Petroleum Science and Engineering, 48*(3–4), 199–208.

American Petroleum Institute (API). (2021). *API Recommended Practice 13B-1: Recommended Practice for Field Testing Water-Based Drilling Fluids* (6th ed.).

Apaleke, A. S., Al-Majed, A., & Hossain, M. E. (2012, February). Drilling fluid: state of the art and future trend. In *SPE North Africa Technical Conference and Exhibition* (pp. SPE-149555). SPE.

Bergane, C., & Hammadi, L. (2020). Impact of organophilic clay on rheological properties of gasoil-based drilling muds. *Journal of Petroleum Exploration and Production Technology*, *10*(8), 3533-3540.

Bourgoyne, A. T., Millheim, K. K., Chenevert, M. E., & Young, F. S. (1986). *Applied Drilling Engineering*. Society of Petroleum Engineers.

Caenn, R., Darley, H. C. H., & Gray, G. R. (2017). *Composition and Properties of Drilling and Completion Fluids* (7th ed.). Gulf Professional Publishing.

Caenn, R., Darley, H. C., & Gray, G. R. (2011). *Composition and properties of drilling and completion fluids*. Gulf professional publishing.

Darley, H. C. H., & Gray, G. R. (1988). *Composition and Properties of Drilling and Completion Fluids* (5th ed.). Gulf Publishing Company.

De Paiva, L. B., Morales, A. R., & Díaz, F. R. V. (2008). Organoclays: properties, preparation and applications. *Applied clay science*, *42*(1-2), 8-24.

Gaurina-Međimurec, N., Pašić, B., Mijić, P., & Medved, I. (2021). Drilling fluid and cement slurry design for naturally fractured reservoirs. *Applied Sciences*, *11*(2), 767.

Mahmoud, A., Gajbhiye, R., & Elkatatny, S. (2023). Application of organoclays in oil-based drilling fluids: a review. *ACS omega*, *8*(33), 29847-29858.

Mainye, W., & Teutsch, M. B. (2016). *U.S. Patent Application No. 14/911,156*.

Mei-Chun Li, Dongqing Yang, Jinsheng Sun, Kaihe Lv, Yaxuan Zhang, Haokun Shen, Qi Wang, Chaozheng Liu. (2025). Weighting Material in Drilling Fluids: Sagging Mechanisms, Influencing Factors, and Prevention Strategies September 26, ACS Omega

Onojake, M. C., & Chikwe, T. N. (2019). Rheological properties of some oil-based muds used in reservoirs in the Niger Delta, Nigeria. *Global journal of pure and applied sciences*, *25*(1), 39-44.

Onuh, C. Y., Dosunmu, A., Anawe, P. A. L., Okoro, E. E., Igwilo, K. C., & Ehinmowo, A. B. (2020). The rheological behavior of a pseudo-oil-based mud formulated with Hura crepitans plant oil as base fluid. *Journal of Petroleum Exploration and Production Technology*, *10*(1), 71-89.

Ratkievicius, L. A., Da Cunha Filho, F. J. V., Neto, E. L. D. B., & Santanna, V. C. (2017). Modification of bentonite clay by a cationic surfactant to be used as a viscosity enhancer in vegetable-oil-based drilling fluid. *Applied Clay Science*, *135*, 307-312.

Riley, M., & Fink, J. K. (2016). *Petroleum Engineer's Guide to Oil Field Chemicals and Fluids*. Gulf Professional Publishing. This reference discusses the influence of temperature on drilling fluid viscosity, particle interactions, and rheological performance under field conditions.

Zhuang, G., Zhang, Z., Peng, S., Gao, J., & Jaber, M. (2018). Enhancing the rheological properties and thermal stability of oil-based drilling fluids by synergetic use of organo-montmorillonite and organo-sepiolite. *Applied Clay Science*, *161*, 505-512.