Laboratory Evaluation of Local Albanian Clays for Water-Based Drilling Fluids: A Case Study in the Patos-Marinza Oil Field

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Abstract: - In this study we have evaluated the potential of locally sourced clays from the Patos region to be used as base material for water-based drilling fluids in the Patos-Marinza oil field. Four drilling fluid formulations with densities ranging from 1.05 to 1.20 g/cm³ were prepared and tested for density, suspension stability, sedimentation, sand content, filtration, and rheological behavior. The results show that while Patos clays provide acceptable rheological properties and low hydraulic resistance, they have relatively high filtration values and sand content, which may lead to serious problems. In order to overcome this disadvantage, we may need to use additives and filter the clay before use. From an economic perspective, the higher clay dosage and processing costs make them less competitive than imported bentonite under current conditions. However, their favorable flow characteristics suggest potential for use in deeper wells or alternative applications, provided further optimization is carried out.

Key-Words: - Local Clays, Drilling Fluids, Rheology, Filtration, Oil Field, Feasibility.

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1 Introduction

Drilling fluid performs multiple functions beyond cuttings transport, [1]. Most of these functions are carried by the mixture of water and clay, although additional additives are also included, [2]. These components control key fluid parameters such as density, viscosity, and filtration properties, which determine overall performance. Since this study focuses on clays, it is important to understand how their mineralogical composition and concentration influence drilling fluid density and viscosity, [3]. Proper density ensures adequate hydrostatic pressure to prevent formation influx, while clays contribute to thixotropic behavior and filter cake formation that stabilize the wellbore, [4]. The role of drilling fluids is particularly relevant in the Patos-Marinza oil field, Albania's largest oil-producing region, characterized by heavy crude production, extensive surface area, and complex geological conditions, [5]. More than 2,500 wells have been drilled, with approximately 600 currently active, including production and injection wells, [6]. Despite this, additional drilling remains necessary due to the large field area, untapped upper reservoirs such as Goran, and increased demand from cyclic steam injection projects, [7], [8], [9]. Under these conditions, optimizing drilling costs is essential, motivating the evaluation of local clays for drilling fluid preparation. The study focuses on clays from the Patos region, where Messinian deposits with high clay content and gypsum occur near the surface, reaching thicknesses of up to 380 m and depths exceeding 1,000 m in some areas, [10]. These clays were widely used before the 1990s and have been previously characterized mineralogically [11], but their use declined with the availability of imported bentonite-based clays, creating a gap in recent performance data, [12]. This work evaluates the properties of Patos clays, their influence on drilling fluid behavior, and the required technological adjustments, based on experimental analysis of several kilograms of dried and ground clay as described in Chapter 2.

2 Materials and Methods

2.1 Clay density

In this paragraph we have evaluated the density of the Patos-Clays following two different approaches.

2.1.1 Solutions Approach

The first approach involves determining the clay density by measuring the density of the solution it forms. A drilling mud will be prepared using water and clay. To start, the density of the water will be determined. Distilled water is avoided intentionally, as the water used on-site is typically fresh water with a certain mineral content. This ensures that the physicochemical interactions between the water and the clay are considered, as these interactions may cause the volume of the formed solution to differ from the sum of the volumes of its components.

For this, a densimeter (mud balancer) is used [13]. The device is filled with fresh water, and the lid is placed on top, which has a small hole to remove excess fluid. The mud balancer is then placed on its base, which functions as a holder, and the reader is adjusted until balance is achieved between the cup and the counterweight. Fresh water at room temperature was first measured, with a density of 1.00 g/cm³. In total, 400 g of clay was mixed with 800 mL of water in a metal container. The mixture was mechanically stirred for 10 minutes. After mixing, the drilling fluid was moved to a densimeter, where its density was measured as 1.22 g/cm³. To check if readings hold steady, the whole process was repeated three more times.

The mass of the solution comes from adding up the amounts of everything it's made of:

$$m_s = m_c + m_w \quad (1)$$

where: m_s – mass of the solution;
m_w – mass of the water;
m_c – mass of the clay;

On top of that, we're thinking its size matches up exactly with what you get when adding together the sizes of each part it's made of:

$$Vs = Vc + Vw \quad (2)$$

where: V_s – volume of the solution;
V_w – volume of the water;
V_c – volume of the clay;

By solving the system composed of Equation (1) and Equation (2), in function of determining the density of the clay, we arrive at the conclusion of Equation (3) that:

$$\rho_c = \frac{\rho_s m_c}{m_c + V_w(\rho_w - \rho_s)} \quad (3)$$

where:
ρ_c – density of clay;
ρ_s – density of solution =1.22g/cm^3 (measured);
ρ_w – density of fresh water =1.00g/cm^3 (measured);
Clay comes in at a density of roughly 2.18 g/cm^3.

2.1.2 Pycnometer Approach

The second approach involves using a pycnometer, [14]. A small glass pycnometer holds 50ml of measured volume. Its empty weight comes in at 45g, labeled m_1. Then we add 30g of clay into the pycnometer, the balance reflects 75g, labeled as m_2. After that, the pycnometer was fully filled with water. That total is 186.5g, marked m_3. With that done, the pycnometer was drained and then filled again - this time just with distilled water. Its weight comes in at 125g, labeled as m_4. So finally, we insert the values into Equation (4) to calculate the density of the clay:

$$\rho_c = \frac{m_2 - m_1}{\frac{m_4 - (m_3 - m_2)}{\rho_w}} \quad (4)$$

The density of the clay is found to be ρ_{c2} =2.2 g/cm³. For the reasons explained in Chapter 3, we will consider the density of the clay to be 2.2 g/cm³ in this chapter. Now, that the densities of the drilling fluid components are determined, the necessary formulations for preparing solutions with different densities can be established. As seen in Table 1, four different solutions have been prepared, each with a volume of 5000 cm³. This volume is necessary to ensure an adequate amount of solution for measuring the other properties of the drilling fluid.

Table 1. Different drilling fluid solutions prepared in the laboratory

Solution	Density [g/cm^3]	Volume [cm^3]	Clay weight [g]	Water volume [cm^3]
Sol.1	1.05	5000	458	4791
Sol.2	1.1	5000	916	4583
Sol.3	1.15	5000	1375	4375
Sol.4	1.2	5000	1833	4166

Source: created by the authors

2.2 Suspension Stability, Sedimentation and Sand Content

Suspension stability is a property of drilling fluid used to evaluate the consistency of its characteristics. Suspension sedimentation, on the other hand, is a physical property of the drilling fluid that indicates the stability of its structure.

In the laboratory, for each of the four drilling fluid solutions, two graduated cylinders will be filled with 1000 mL of solution each (for a total of 8 cylinders). These cylinders will remain undisturbed for 24 hours. After this time, the amount of water that has separated from the solution and moved to the top portion of the cylinder will be observed and recorded. Then, 500 mL from the top portion of each cylinder will be transferred to a metal glass, stirred with a stirrer rod, and its density will be measured using a densimeter (mud balancer). The same procedure will be repeated for the bottom 500 mL of each cylinder.

As seen in Equation (5), the difference in density between bottom and the top portions indicates the suspension stability, while the ratio of the volume of separated water to the total solution volume, expressed as a percentage, indicates the sedimentation of the drilling mud [15], as seen in Equation (6).

$$\text{Stb}\ (\text{g/cm}^3) = \rho_{btm} - \rho_{top} \tag{5}$$

$$\text{Sed}(\%) = \frac{V_{spw}}{V_{dmc}} * 100 \tag{6}$$

where: Stb – drilling mud stability;
ρ_{btm} – density of the bottom 500ml of the cylinder;
ρ_{top} – density of the top 500ml of the cylinder;
Sed – drilling mud sedimentation;
V_{spw} – volume of the separated water;
V_{dmc} – volume of the drilling mud in the cylinder (=1000cm^3);

Sand in drilling fluid means how much is sand big enough (above 74 microns). That sand often comes from digging into rock layers, dirty conditions, or using low-grade heavy additives. When there's too many sand bits, machines grind down faster, walls of the hole strip away, plus turning the pipe gets harder, [16].

A 50 mL sample of the prepared drilling fluid was mixed with 450 mL of water and stirred to ensure uniform distribution of sand particles. The mixture was then left undisturbed for 24 hours to allow sedimentation. After this period, the settled sand at the bottom of the container was collected and measured. As seen in Equation (7), the sand content was determined as the ratio of the settled sand volume to the initial drilling fluid volume. This procedure is repeated for all the prepared drilling fluid solutions to assess their sand content.

$$\text{SC}\ (\%) = \frac{V_{sp}}{V_{dmc}} * 100 \tag{7}$$

where:
SC – drilling mud sand content;
V_{sp} – volume of the sand particles at the bottom of cylinder;
V_{spw} – volume of the drilling mud in the cylinder (=50cm^3);

2.3 Filtration and Filter Cake

Filtration is a key property of drilling fluids that controls fluid loss to the formation under differential pressure. As the drilling fluid pressure exceeds that of the surrounding rock, the liquid phase filters into pores and fractures, while solid particles, like dispersed clay, accumulate on the wellbore walls. This forms a filter cake, which minimizes further fluid loss and stabilizes the borehole, [17].

Checking filtration rates and how thick the filter cake gets shows whether drilling muds keep the wellbore steady and protect the rock around it. Too much fluid escaping might cause the hole to shift, stick, or slow down progress. At the same time, the layer's thickness, density, and low flow rate influence how much mud enters the formation. Measuring these values helps adjust drilling fluid mixes to work better while cutting down on problems, [18]. In the laboratory, the HPHT (High-Pressure High-Temperature) filtration apparatus will be used to measure the filtration values and filter cake thickness for each of the prepared solutions, [16]. The device's body cell is equipped with a filter at the bottom and is filled with the required volume of drilling fluid. Once sealed, the top assembly is installed, which includes a gas inlet section and two valves that regulate the pressure applied to the drilling fluid inside the chamber. The body cell is placed in a heating jacket containing resistive elements that gradually heat the fluid to the desired temperature. Pressurized gas cylinders supply the necessary pressure to simulate downhole conditions and control the filtration process.

Once the temperature and pressure reach the desired values, the valve connecting the top section to the body cell is opened, allowing the drilling fluid to filter for 30 minutes. When the test finishes, we record how much liquid passes through. We also check the depth of the layer that builds up above the filter surface.

Gas cylinders will be generating pressures ranging from 100 to 500 psi for every mud setup. Linearity is likely to appear when it comes to how much fluid filters through, depending on the applied pressure; that behavior follows what Darcy's law describes about moving fluids via porous media. According to this principle, the rate of fluid loss increases proportionally with the applied pressure difference across the medium.

Changes in temperature will also shape how much liquid passes through the filter - along with how thick the filter cake becomes. We have tested four distinct temperatures: 25°C (77°F), 37.7°C (100°F), 93.3°C (200°F), and 121°C (250°F). The reason those numbers made the cut comes down to what the HPHT setup can actually handle under high pressure and heat.

2.4 Rheological Models and Parameters

Drilling fluids exhibit different flow behaviors depending on their composition and the forces applied to them. To describe and predict their behavior under various shear conditions, rheological models are used. The most commonly applied models in drilling fluid analysis include the Newtonian model, Bingham Plastic model, and Pseudoplastic model (Power-Law model). Each model characterizes the relationship between shear stress (τ) and shear rate (dv/dr), [19].

Equation (8) shows that in a Newtonian fluid, the shear stress is directly proportional to the shear rate.

$$\tau = \mu_{ef} * \left(\frac{dv}{dr}\right) \tag{8}$$

The proportionality constant is the effective viscosity μ_{ef} (cp), which remains constant regardless of the applied shear rate. These fluids do not exhibit a yield stress, meaning they begin to flow immediately when a shear force is applied.

The Bingham Plastic model describes fluids that require a minimum stress [yield stress, τ_0 (din/cm^2)] before they start to flow. As seen from Equation (9), since this yield stress is exceeded, the relationship between shear stress and shear rate becomes linear and the proportionality constant is the plastic viscosity μ_p (cp).

$$\tau = \tau_0 + \mu_p * \left(\frac{dv}{dr}\right) \tag{9}$$

Equation (10) shows the relationship that follows the Power-Law equation:

$$\tau = k * \left(\frac{dv}{dr}\right)^n \tag{10}$$

where: k- Flow consistency index (Pa·s^n or eq.cp), representing the fluid's viscosity at a reference shear rate;
n- Flow behavior index (dimensionless)

In the laboratory, a Fann viscometer was used to measure shear stress by rotating a cylinder in the drilling fluid, [15]. Measurements were taken at six rotational speeds: 3, 6, 100, 200, 300, and 600 RPM, corresponding to shear rates of 5, 10, 170, 340, 510, and 1020 s^{-1}, respectively. At every shear rate, the shear stress will be recorded across six levels. Two temperatures are used: 25°C and 37.7°C. For each rate level, a reading appears as Φ, tagged with a code showing exactly which rate it answers. For example, Φ_{600} represents the shear stress measured at a shear rate of 1020 s^{-1} and so on for the other rotational speeds.

Once these values are recorded, we will be able to calculate the rheological parameters for each rheological model (Newtonian, Bingham Plastic, and Pseudoplastic) for all four solutions using Equation (11), Equation (12) and Equation (13).

$$\mu_{ef} = \frac{1}{2}\Phi_{600} \tag{11}$$

$$\mu_p = \Phi_{600} - \Phi_{300} \tag{12}$$

$$\tau_0 = 4.79 * (\Phi_{300} - \mu_p) \tag{13}$$

The values of *k* and n will be calculated by fitting the power-law model to the measured data.

Additionally, the Gel strength parameter will also be measured as seen in Equation (14). Gel strength values (Gel lb/100ft^2) indicate the fluid's ability to suspend cuttings.

$$Gel = \Phi_3 \tag{14}$$

3 Results and Discussions

This section presents the experimental results, including key drilling fluid properties, and provides an initial assessment of the feasibility of using Patos clay under representative field conditions.

3.1 Experimental Results

The experimental analysis provides insight into the physical, filtration, and rheological properties of drilling fluids made with Patos clays. Tests on density, stability, sand content, and filtration help explain how the clay behaves and whether it is suitable for drilling. Clay density was determined using both solution and pycnometer methods, giving reliable results for further calculations. The fluids showed relatively stable behavior in sedimentation tests, while changes in composition influenced phase separation. Filtration tests under different pressure and temperature conditions highlighted their impact on fluid loss and filter cake formation. Overall, the results help assess how these clays may perform under real field conditions in the Patos-Marinza area.

3.1.1 Density of Patos Clays

A gap shows up when comparing density numbers from both methods. Difference sits at 0.02 g/cm³, which translates to 0.91% relative error. That narrow spread comes from factors like air trapped after grinding, tiny contaminants in the clay, how water mixes with it altering liquid volume, plus minor shifts in how measurements are taken. Additionally, the assumption in Equation (2) that the solution volume equals the sum of the component volumes may slightly amplify these effects but is not a separate independent factor.

Based on repeated measurements and assuming a small experimental variability, the 95% confidence intervals were calculated as 2.16–2.20 g/cm³ for the solution method and 2.18–2.22 g/cm³ for the pycnometer method, confirming consistency between the two approaches.

When calculating the fluid volume using a clay density of 2.2 g/cm³ (from the pycnometer), the total volume is taken as the sum of its components, according to Equation (2). If the density of 2.18 g/cm³ from the solution method is used instead, the calculated volume changes as seen in Equation (15):

$$V_s = V_w + \alpha V_c \tag{15}$$

where: α – clay volume coefficient and is calculated as shown in Equation (16);

$$\alpha = \frac{V_{true}}{V_{calc}} = \frac{m_c/\rho_{c2}}{m_c/\rho_{c1}} = \frac{\rho_{c1}}{\rho_{c2}} = 0.990 \tag{16}$$

V_{true} - true volume of the clay (calculated using the density measured in pycnometer);
V_{calc} – calculated volume of clay (calculated using the density from the first approach);

3.1.2 Stability, Sedimentation, and Sand Content of Patos Clay Solutions

The results show how clay content affects different aspects of drilling fluid behavior, mainly depending on mixture density. Higher stability values indicate less consistent fluid properties, while increased sedimentation points to a weaker structure. Sand content plays a key role, as higher levels increase friction during flow and accelerate equipment wear, leading to higher maintenance costs. All results are presented in Figure 1.

These results indicate a direct correlation between the density of the examined solution and its stability, sedimentation, and sand content. When the solution gets denser, it can't hold up as well under stress. More sand mixed in tends to go along with that weakening effect.

Looking at Figure 1, higher sedimentation and stability readings point to weaker structural integrity. This is mainly linked to the composition of Patos clays, which lack significant amounts of montmorillonite, a mineral that typically helps thicken suspensions. As more clay is added, the fluid becomes heavier. Heavier suspensions tend to pull more solid particles downward. These particles settle instead of remaining suspended. At the same time, fluid viscosity increases, which helps keep particles in motion. However, the rate at which density increases is greater than the gain in fluid resistance, ultimately leading to reduced stability at higher masses.

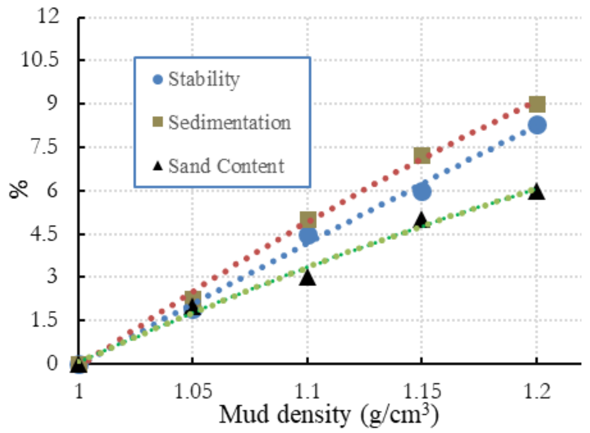

Fig. 1: Relationship Between Fluid Density, Stability, Sedimentation, and Sand Content
Source: created by the authors

Sand that is found in the mud comes straight from the clay we put in it. Consequently, increasing the clay content in the solution (and thus its density) also proportionally increases the sand content. This explains the nearly linear relationship between fluid density and sand content. Conversely, stability and sedimentation exhibit a polynomial quadratic relationship with fluid density. Their values change rapidly at lower densities but stabilize as density increases. Considering the drilling dynamics in the Patos-Marinza oilfield, stability and sedimentation values do not pose significant concerns. Well depths range from 1000 to 1800 meters, which plays a role along with improved drilling methods. Yet even with these factors, sand mixed into the fluid still causes problems. High sand amounts accelerate damage to equipment inside the drill. Between 0.5% and 1%, sand levels are considered acceptable in drilling operations. For Patos clay to function well during fluid mixing, removing bulk debris is important. A step like that uses fine screens or specialized filters. It captures any material larger than 72 microns before proceeding. This approach allows the fluid's rheological properties to adjust in ways that improve stability while reducing frictional impact on drilling equipment.

3.1.3 Filtration and Filter Cake thickness of Patos Clay Solutions

The results presented in Figure 2, Figure 3, Figure 4 and Figure 5 demonstrate clear trends in filtration volume and filter cake thickness under varying pressure, temperature, and solution density. When pressure climbs from 100 psi up to 500 psi, each measure climbs too - especially in denser mixes. Higher temperatures at 121 °C push more liquid through, increasing filtration volume and thickening the cake layer because lower viscosity allows easier flow. The density of the mix also affects the results, denser solutions form thinner cakes, suggesting that their higher solid content and viscosity slow down fluid movement.

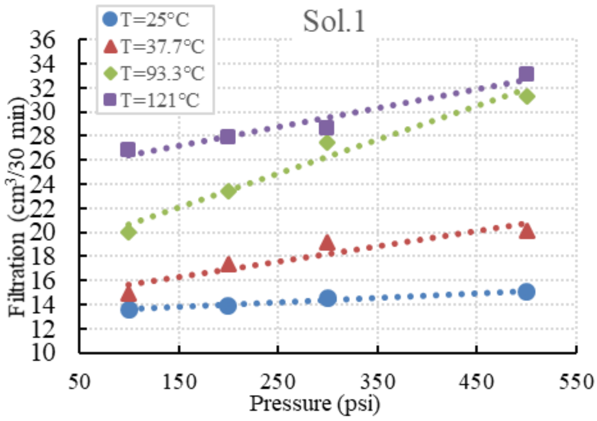

Fig. 2: Filtration behavior of solution 1 as a function of pressure and temperature

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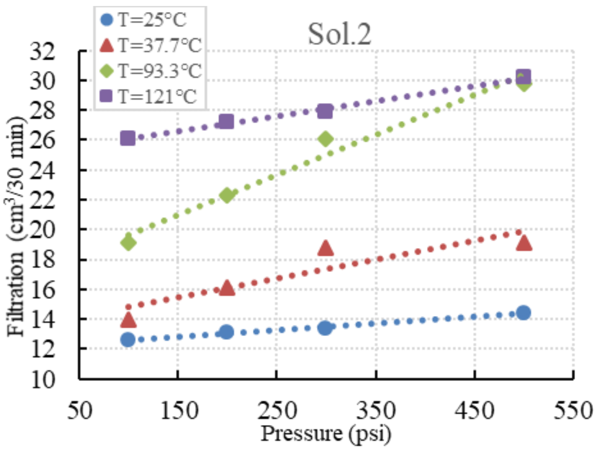

Fig. 3: Filtration behavior of solution 2 as a function of pressure and temperature

Source: created by the authors

Looking at everything, pressure, temperature, and fluid density all shape how filtration behaves, with density standing out as especially important. In the Patos-Marinza field, rock layers increase by about 21.3°C for each kilometer underground [20], meaning wells may reach temperatures near 38 °C. Under these conditions, filtration values would range between 9.3 cm³/30 min and 17.4 cm³/30 min. On top of that, the material building up in the filter could range from just under 1 mm to about 5 mm in thickness.

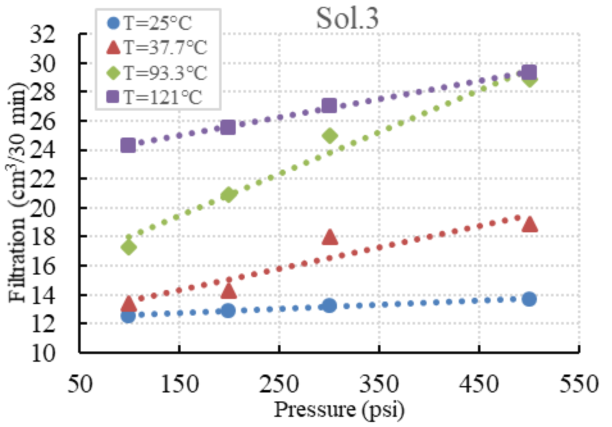

Fig. 4: Filtration behavior of solution 3 as a function of pressure and temperature.

Source: created by the authors

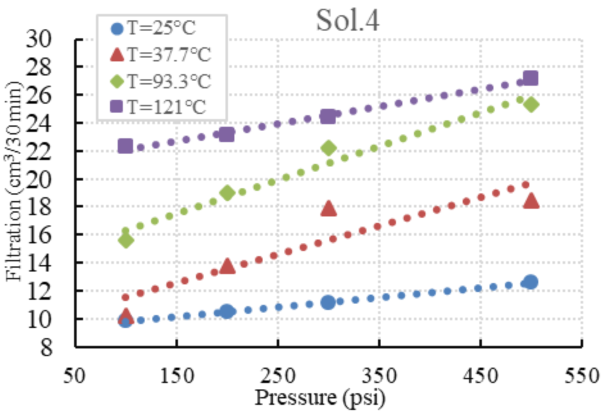

Fig. 5: Filtration behavior of solution 4 as a function of pressure and temperature.

Source: created by the authors

A small amount of measurement spread exists around ±0.1 to ±0.2 cm³ for filtration, while cake thickness varies by about ±0.5 mm. Filtration values exceeding 10 cm³ may be unacceptable without additional fluid-loss control additives, while filter cake thicknesses above 3 mm may increase friction and sticking risk [21]. Therefore, performance may be improved through additives that promote thin, low-permeability filter cakes and optimization of drilling fluid composition with high-quality bentonite.

3.1.4 Rheological Models and Parameters of Patos Clay Solutions

Differences in effective viscosity, plastic viscosity, yield stress, and flow behavior stand out across

Solutions 1–4. These shifts come from variations in solids level and heating temperature. When the temperature rises (from 25 °C up to 37.7 °C) the same trends appear: η_ef drops, η_p shrinks, τ_0 falls. Across the four solutions, η_{ef} ranges approximately from 0.75 to 5.75 cp at 37.7 °C and from 1.0 to 5.75 cp at 25 °C, while plastic viscosity varies from about 0.7 to 4.8 cp over the same temperature range. Yield stress increases progressively from Solution 1 to Solution 4, spanning approximately 0.48–10.06 dyn/cm², with lower values observed at the higher temperature. When warmer, the thinner mixes shift more noticeably because molecules barely hold together, gliding freely.

As seen in Figure 6 solution 1 behaves nearly like a Newtonian fluid, with no yield stress and no change in viscosity with shear. Its low resistance means it struggles to suspend cuttings during flow.

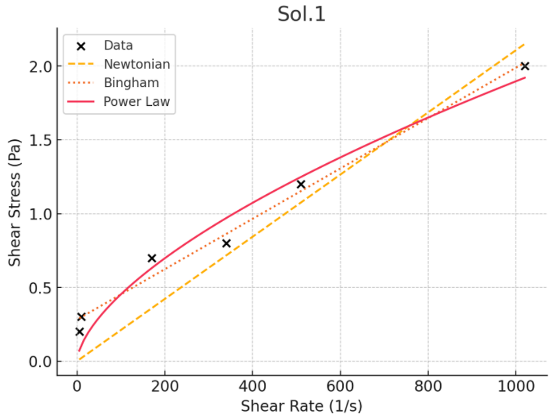

Fig. 6: Fitting of the three rheological models for solution 1
Source: created by the authors

In contrast, as seen in Figure 7, Figure 8 and Figure 9, Solutions 2 through 4 do not behave the same way. Their resistance decreases with shear rate, showing shear thinning behavior.

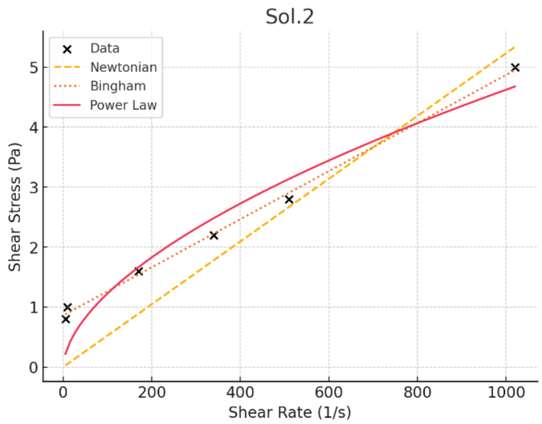

Fig. 7: Fitting of the three rheological models for solution 2
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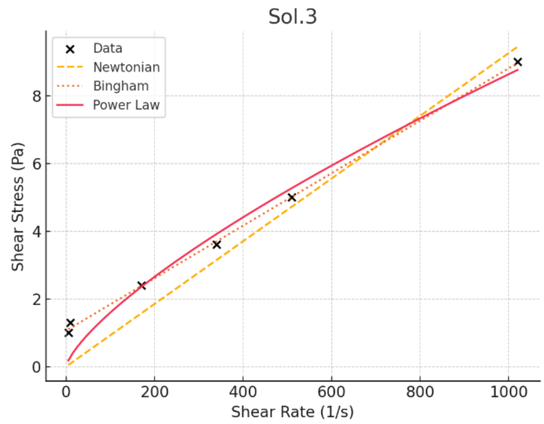

Fig. 8: Fitting of the three rheological models for solution 3
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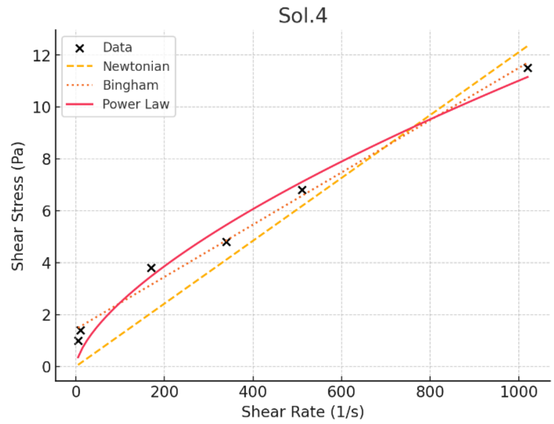

Fig. 9: Fitting of the three rheological models for solution 4
Source: created by the authors

This is reflected in the values of k (1.44–10.06) and n (0.29–0.43). What stands out is how they thin at higher shear rates (making mixing easier) while still maintaining smooth flow during pumping

Gel strength for these four solutions varies roughly between 0.1 and 1.0 lb/100 ft², increasing with solution density and indicating improved structural buildup for cuttings suspension.

Rheological measurements were repeated three times for each solution. The calculated deviations range between 5–10% for apparent and plastic viscosity, approximately 10% for yield stress, 10–15% for the consistency index, about 0.05 for the flow behavior index, and 5–10% for gel strength. These variations reflect the combined influence of instrument precision, temperature control, and sample handling.

The rheological model fitting shown in Figure 6, Figure 7, Figure 8 and Figure 9 indicates that Solution 1 can be well approximated by the

Newtonian model, while Solutions 2–4 are adequately represented by the power-law model, confirming their pseudoplastic behavior.

The viscosity values show one of the main advantages of Patos clays, they can reach higher densities without becoming too viscous. In practice, this makes them suitable for deep well drilling, since they keep hydraulic losses relatively low while still helping maintain wellbore stability.

3.2 Pre-Feasibility and Future Prospects

After analyzing all the characteristics of these clays, we can also try to assess whether their implementation in this oil field is feasible. Drilling a well in Patos-Marinza, from the perspective of technological fluids, goes through four sections as shown in Table 2.

Table 2. Drilling Mud Parameters Used in Well Drilling in Patos-Marinza

Depth (m)	Mud density (g/cm^3)	Filtration (cm^3/30min)	Viscosity (cp)
0-109	1.05	10	8
109-1092	1.1	8	12
1092-1156	1.15	5	15
1156-1800	1.1	8	12

Source: created by the authors

The density of the drilling fluid is controlled by the formation pressure gradient and therefore remains the same whether bentonite or Patos clay is used; consequently, Solutions 1–3 are considered.

Because Patos clay has a lower density (2.2 g/cm^3) than bentonite (2.6 g/cm^3), approximately 18.18% more Patos clay (by volume) is required to achieve the same mud density, increasing solid content, equipment wear, and reducing drilling speed as part of the bit load is absorbed by solids, ultimately raising drilling costs. In addition, the high sand content of these clays requires pre-treatment, further increasing costs. Filtration values under Patos-Marinza conditions range from approximately 14–20 cm^3/30 min (Solutions 1–3, up to 38°C), exceeding recommended standards [22] and requiring additives to reduce fluid loss, which increases operational costs. On the flip side, Patos clays act differently - their viscosity stays much lower than bentonite, leading to hydraulic losses between 1.5 and 2 times smaller. Because of this, pump requirements drop, which means less power needed to pump fluids through the well. These details are laid out clearly in Table 3, showing how costs break down when making 100 m^3 of fluid at 1.1 g/cm^3 using either type of clay.

Table 3. Cost Comparison Between Normal Bentonite and Patos Clays

Factors	Cost ($)	
	Bentonite	Patos Clays
Clay Mass	4,875	3,667
Sand Filtration	-	916
Filtration-lower additives (CMC)	-	3,750
Electric Energy (pump)	5,508	3,672
Total	**10,383**	**12,005**

Source: created by the authors

The comparison focuses on the last interval of the well, from 1156 m to 1800 m, as this section reaches the maximum depth, where hydraulic losses are highest and most of the pump power is used to overcome these losses rather than maintain flow rate. Additionally, most of the mud used for drilling this interval is prepared anew to minimize formation damage. The fluid is pumped by a 600 kW pump for approximately 60 hours, as practiced in the Patos-Marinza Oil Field. Although Patos clay has a lower base price (200 $/ton) than bentonite (300 $/ton) [23], additional costs arise from sand filtration (≈50 $/ton) and the use of CMC at about 15 kg/m³ to reduce filtration [24] from approximately 19.1 cm³ (Solution 2, 38°C, 500 psi) to 8 cm³, at 2.5 $/kg, [25]. While improved rheology reduces hydraulic losses by about 40% (plastic viscosity decreases from 12 cp for bentonite to 2.1 cp for Patos clay under turbulent flow), lowering energy consumption at an electricity price of 0.153 $/kWh [26], the overall cost remains higher for Patos clays.

Therefore, from an economic perspective, Patos clays are unsuitable for application in the Patos-Marinza oilfield, even under maximum energy-saving conditions. Despite this, they still meet the basic requirements for drilling fluids and could perform well in deep wells due to their good flow behavior, suggesting that further study is needed, especially regarding their potential impact on local communities near Patos.

4 Conclusion

Patos clays have suitable mineralogical and chemical properties for use in drilling fluids, with favorable rheological behavior, especially their ability to maintain relatively low viscosity at higher densities, which supports their potential application in deep well drilling. Early laboratory results suggested that these clays could be applicable beyond a single field; however, the Patos-Marinza field was selected because it is currently the only reservoir in Albania where new wells are actively being drilled, with activity increasing due to enhanced oil recovery (EOR) operations, [6], [7], [8], [9]. It was also the only field where reliable operational data were available for a meaningful comparison.

While filtration and filter cake properties are acceptable for most drilling conditions, additional fluid-loss control additives may be required in high-permeability formations. From an economic perspective, the higher clay dosage compared to bentonite, together with the costs of sand removal and filtration, makes Patos clays less competitive for the Patos-Marinza field, where imported bentonite remains inexpensive. Nevertheless, their low hydraulic losses and stable behavior indicate technical potential, and their use could still offer local economic benefits.

Although the results do not support immediate economic application in Patos-Marinza, the study provides a useful basis for future work in other settings. Deeper prospects such as the Shpiragu reservoir, recently tested by Shell and currently on standby, include wells reaching approximately 5500–6200 m, where optimized use of local clays could contribute to lowering drilling costs in the future, [27]. Further research should focus on improving filtration performance, reducing sand content, and reassessing economic feasibility under different field conditions.

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