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The Use of Locally Sourced Ginger as Weighting Material in Drilling Mud

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Abstract

A good mud program necessitates a successful Petroleum drilling operation. Barite is the prevalent weighting material but there is need to develop cheap local materials to substitute the use of Barite as foreign materials are expensive. This paper investigates the suitability of ginger, as an alternative weighting material in drilling muds. API RP-13B standard procedures were employed throughout the laboratory work to determine mud properties. Two mud samples A and B were prepared which comprised fresh water, Q-Broxine, bentonite and weighting material. The weighting materials were added to the mud separately to form the required mud weight ranges between 8.0 ppg and 11.0 ppg. Sample A was water-based mud with foreign barite while Sample B was water-based mud with local ginger. These samples were analyzed and the density, rheological properties and sand contents were analyzed. At 8.0 ppg, the yield point of ginger was 18.0 lb/100ft^2 and barite 14.0 lb/100ft^2 while the 10 second gel strength of ginger (Zingiber officinale) was 6.0 lb/100ft^2 and 3.0 lb/100ft^2 for barite. Similarly, little difference was observed in plastic and apparent viscosities. At 8.0 ppg, the plastic and apparent viscosities of ginger was13.0 cP and 22.0 cP while barite was 12.0 cP and 19.0 cP

1. Introduction

Surface Drilling mud, also known as drilling fluid in petroleum engineering is a heavy, viscous liquid mixture that is used in oil and gas drilling operations to carry rock cuttings to the surface and also to lubricate and cool the drill bit [1]. As a result of expected increase in drilling activities, there is the need to source for alternative drilling mud additives so as to minimize the importation of weighting materials like barite. The drilling mud is usually formulated to have adequate hydrostatic pressure, normally in the range of 250 psi to 450 psi higher than the formation pressure [2]. Imbalance between the hydrostatic pressure and the formation pressure may cause influx of formation fluid which may result in a kick and eventually a blowout. Weighting materials increase mud density as well as penetration rate during drilling [3]. A locally obtained weighting material that can be used in place of barite would be a new innovation in the industry.

The main objective of the research is to examine the properties of a locally sourced material to substitute barite in drilling fluids. In the paper, the rheological properties of ginger were examined and compared with that of barite.

1.1 Basic Properties of Ginger and Barite

Ginger is a herbaceous perennial grown as an annual for its spicy underground rhizomesor stems. The plant has fibrous roots that emerge from the branches rhizomes. It takes about 6 weeks for shoots to emerge after ginger has been planted. Vegetative growth is maximized until flowering begins in September – October. Flowering marks the beginning of rhizomes maturity and increasing fibrous tissue development [2]. Nigeria produces an average of 50,000 metric tonnes of fresh weight ginger per annum [3]. About 10% of the produce is consumed locally as fresh ginger while the remaining 90% is dried for both local consumption and export. According to [3], 20% of the dried ginger is consumed locally for various uses and 80% is exported. Barite is an inorganic compound that is white crystalline in appearance, insoluble in water and colourless. It can be heated with coke to give barium sulfide (BaS) which is soluble in water unlike $BaSO_4$. It has a molar mass of 233.4 g/mol, and is odourless. It has a melting point of 1345ºC, boiling point of 1600ºC and refractive index of 1.64. The hardness is 3.0 and specific gravity is 4.5. Although, barite has a slightly higher molecular weight than galena (243.4 to 239.3) the molecular composition of lead in galena is higher (86.60%) than barium in barite (60.54%) in pure samples [4]. According to Simpson [5], important properties of drilling mud include: Density (which enhances borehole stability and prevents blowout); low viscosity and gel strength (which produce faster drilling and more efficient removal of drill cuttings). The main role of the weighting materials in the drilling fluid is to increase density and ultimately to ensure borehole stability [6]. It also creates sufficient hydrostatic pressure in the hole and minimizes fluid loss by formation of thick filter cake on the walls of the well [7].

2. Methodology

2.1. Sample Collection and Preparation

The local ginger was bought from New Benin Market in Benin City, Edo State. Two mud samples were prepared which comprised of fresh water, Q-Broxine, bentonite and the weighting material. The weighting materials were added to achieve the required density. The experiment was carried out in two phases:

- Stage1: Formulation of Sample A containing water-based mud with foreign barite of density between 9.0 ppg and 12.0 ppg.
- Stage2: Formulation of Sample B water-based mud with ginger of density between 9.0 ppg and 12.0ppg

The ginger sample was dried at temperature of 60 ℃ by spreading out in a steel tray in a drying oven for 8 hours at atmospheric condition. The dried sample was then pounded in a mortal and sieved to obtained fine powdered clay particles of 250 microns size.

2.2. Determination of Drilling Mud Properties

API RP-13B standard procedures (API practices 13B section 5**)** were employed throughout the laboratory work to determine mud properties. All the mud samples were based on the formulation of 350 ml of fluid that contains only fresh water.

2.2.1. Determination of Rheological Properties

This was done to obtain the rheological properties of the mud such as viscosity at 600 rpm and 300 rpm, 10 minutes and 10 seconds gel strength, plastic viscosity and yield stress. The equipment used was an OFITE 900 Model viscometer.

2.2.2. pH Determination

To determine the pH of the mud, the following were followed; the freshly prepared mud was re-stirred to obtain homogeneous mixture. About one-inch strip of the ph-hydrion dispenser paper was removed and placed gently on the surface of the mud and sufficient time was allowed to elapse (about few seconds) for the paper to soak up filtrate and change color. The soaked paper strip was matched with chart on the dispenser from which the strip was taken. The pH range of the mud was read and the value recorded.

2.2.3. Determination of Mud Weight

The mud density test was conducted in order to determine the weight per unit volume of the mud. Mud density must be great enough to provide sufficient hydrostatic heat to prevent influx of formation fluids, but not so great to cause loss of circulation, damage to the drilled formation, or reduce the rate of penetration (ROP). This test was done to determine whether the prepared local mud samples possessed API minimum weight for oil well drilling. The procedures used to determine the weight of the prepared mud were:

- The instrument base was set up so that it was approximately leveled.
- The freshly prepared mud was poured into a clean, dried mud balance cup and covered with the lid.
- The reading of the mud balance scale was taken and recorded properly against the mud type.
- The mud cup was then emptied, washed, dried and kept for future use.

2.2.4. Determination of Sand Content

The Baroid sand content tube was used to carry out this experiment. API RP-13B standard procedures (API practices 13B section 5**)** were applied in carrying out this experiment.

3. Results and Discussion

The mud formulation is shown in Table 1. The properties were tested after ageing for 24 hours at 60ºC (140ºF). The experimental investigations of mud density, rheological properties and sand content analysis are shown in Table 3. From the results gotten, comparison of the two mud samples was done. Ginger was found to be able to generate similar mud weight as Barite.

Table 1. Water-based mud formulation

Constituent	Weighting Material	
	Barite	Ginger
Fresh Water (ml)	350	350
Bentonite (lb)	0.15	0.15
Q-Broxine (lb)	0.05	0.05
Weighting Material (lb/gal)	8.50	14.50

Table 2. Water-based mud properties at various densities

Mud Property	Weighting Material							
	Barite							Ginger
Mud density (lb/gal)	8.0	9.0	10.0	11.0	8.0	9.0	10.0	11.0
Apparent viscosity (cP)	19	24	31	38	22	27	33	41
Plastic viscosity (cP) ϴ600	38	48	62	76	44	54	66	82
ϴ300	26	32	40	51	31	39	48	59
	12	16	22	25	13	15	18	23
Yield point (Ib /100ft^2)	14	16	18	26	18	24	30	36
10 second gel (Ib /100ft^2)	3	5	8	10	6	8	11	14
10 mins. gel (Ib /100ft^2)	5	8	12	16	8	12	16	22
Sand content (%)	0.1	0.1	0.3	0.3	0.1	0.2	0.4	0.4

3.1 Relationship Between Apparent Viscosity and Mud Density

From Table 2, at 8.0 ppg, the viscosities of barite and ginger were 19 cP and 22 cP respectively and at 11.0ppg, the apparent viscosities were 38 cP and 41 cP respectively. There is a minimal difference of 3cP between the mud samples; thus, ginger could be used as substitute weighting material to barite. This conformed to the report by Akinwumi et.al [8], who reported that on addition of ginger to local mud, the apparent viscosity was 48cP which met API specification of less than 68 cP.

3.2 Relationship Between Plastic Viscosity and Mud Density
From results obtained as shown in Table 2, at density of 8.0 ppg, the plastic viscosity of barite was 12.0 cP while that of ginger was 13.0 cP. It was observed that ginger had a higher viscosity at 8.0ppg and 9.0ppg, and then barite had a higher viscosity at 10.0 ppg and 11.0ppg. This variation could be attributed to the presence of large amount of suspended barite particles in the mud sample, which was more than ginger. This effect continues with increase in mud weight. Therefore, ginger has the potential to be used as weighting material in drilling mud, as it could increase the rate of penetration and hole cleansing efficiency. This was comparable with the observations of Rai and Ohen [9].

3.3 Relationship Between Yield Point and Mud Density
From Table 2, at 8.0 ppg, the yield point of barite and ginger was 14.0 and 18.0 (Ib /100ft^2) respectively while at 11.0 ppg, it increased to 26.0 (Ib /100ft^2) and 36.0 (Ib /100ft^2) respectively. This difference could be ascribed to ginger's attrition being higher than that of barite. But mud with optimal yield point could carry cuttings to the surface in a more efficient and effective manner. This is as cited by Akanaga and Okoro [3].

3.4 Relationship Between Gel Strength and Mud Density
From the results obtained in Table 2, ginger sample has a marginally higher gel strength compared to barite sample. At 8.0 ppg, the 10 second gel strength of ginger and barite was 6.0 and 3.0 (Ib /100ft^2) while the 10 mins gel strength was 8.0 and 5.0 (Ib /100ft^2) respectively. It was observed that there was a marginal increase in the parameter as the mud density increased. The high gel strength may be due to the presence of ions in the ginger.

3.5 Relationship Between Sand Content and Mud Density
The result in Table 2 shows that the sand content increased proportionally with mud density. At 8.0 ppg, the sand content of barite and ginger was 0.1% and 0.1% while at 11.0 ppg; it was 0.3% and 0.4% respectively. Both ginger and barite mud samples had little presence of sand which conforms to API standard requirement for drilling mud. The main advantage of using lower solid content drilling mud is the increase in rate of penetration, due to the presence of fewer solids around the rotating bit.

3.6 Relationship Between pH and Mud Density

The pH of mud containing ginger was found to be at 6.5 compared to tap water of 7.0 pH. This may be attributed to oxidation of the surface of the mineral particles during the grinding to very fine particles. The pH was therefore raised to 11.0 by adding 0.05lb of Q-Broxine. This was comparable with the observations of Rai and Ohen [9].

4. Conclusion
In this paper, ginger was used as a local weighting material in formulating drilling mud. Ginger has the potential to be used as weighting material in drilling fluid as smaller quantity of ginger could produce same mud density as barite. From results obtained, it could be observed that ginger gave a higher yield point and gel strength than barite. The main advantage of ginger over barite is their abrasive characteristics which could be controlled by proper grinding of the mineral into very fine particles. Compared with barite, galena gives a lower sand content due to its higher specific gravity. Comparing galena and barite, differences between the apparent viscosity and plastic viscosity are minimal. The rheological properties of ginger are similar to that of barite and therefore could be used in place of barite.

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