Tiro (Antimony-Sulphide) And Potash As Local Substitutes To Imported Barite And Lignosulphate In Drilling Mud Weighting Additives

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***Abstract*—**A variant of Antimony Sulphide, locally called Tiro (stibnite), which has been used locally for centuries by Northern Nigerian women as a beauty product was employed as a drilling mud weighting material, due to its weight and apparent health safety, as a substitute to expensive and imported Barite. Potash, locally called Kaun, was also used, as a local substitute to Lignosulphate, as a thinner in drilling mud. The implication of using the Tiro and potash were compared with that of barite and Lignosulphate respectively in this research. Results obtained show that less weight of Barite is needed for equivalent weight of Tiro as the mud weight increases and it was also observed that effect of Barite on mud pH is lower than that of corresponding Tiro. Unfortunately, it was observed that the effect of Barite on mud viscosity as weight of Barite in the mud increases has a dangerous effect on the viscosity of the mud. In the case of Tiro, viscosity of mud was maintained until a 5% weight of Tiro in mud. Viscosity is the measure of the ability of the mud to suspend drill cuttings and clean the well for faster drilling. Maintaining viscosity of drilling mud is of paramount importance and for a mud that is employed for drilling dangerous zone, Tiro may be a better alternative to barite if the safety of the well is of high consideration due to Tiro's lower negative effect on viscosity than barite. For the thinners, it was observed that both Lignosulphate and Potash have same reducing influence on weight of mud up to 1.58% weight component of the thinners in the mud mixture after which the potash caused a drastic reduction in mud density with increasing weight percentage of the additive. The two thinners had reducing effect on the pH of mud up to 0.67% weight of additive after which the pH of mud remains constant no matter the increase in percentage thinner additive weight. While potash caused a decrease of 8.7% in pH value, Lignosulphate caused an equivalent 12.6% reduction in mud pH value. This reduction in pH by weighting materials is significant because it makes the mud to become more acidic and pH of a drilling mud actually affects the performance of the mud. Usually mud pH is desirable between 8.0 and 9.0 for optimum hydration [7]. This gives Potash more relevance than Lignosulphate. Also when there is need to rapidly reduce the mud density due to the possibility of lost circulation as a result of over-weight mud, especially when abnormal low pressure zone is encountered during drilling, potash will be a more effective thinner as it caused rapid reduction in mud density. From the observations and measurements carried out during this research, some model equations were proposed.

Keywords-Tiro, Antimony sulphide, Potash, Lignosulphate, drilling mud, weighting additives and thinners.

I. INTRODUCTION

Stroud [1] suggested that driller should consider mud weight more importantly than the mud consistency in use at that time. This he stated is due to the hazard of gas-cutting of thick mud. He also stated that success or failure in drilling a well in the Monroe (La.) gas field depended upon the control of the gas pressure by heavy mud. Based on various laboratory tests using cement, galena and iron oxide (hematite, Fe_2O_3) as materials for increasing the density of mud it was discovered that. Iron oxide could be used to raise mud density to 16 Ib/gal without an excessive increase in consistency of the mud thereafter it was used successfully in several fields. In the fall of 1922, pigment-grade Missouri barite was used as a weighting material to make a heavy mud.

Wayne [2] introduced the first mud thinning agent and it was a mixture of chestnut bark extract and sodium aluminates called Stabilite. It was discovered that it was able to thinned mud without decreasing the mud density and also caused a released of entrapped gas, thereby allowing further increase in mud weight for higher pressure control. The composition of the Stabilite was later altered to include molecularly dehydrated phosphates as a component.

Okumo [3] carried out research on the effect of temperature and potash on drilling mud. They employed the principle and method of factorial design to develop a model. They used the model for prediction of drilling fluid viscosity at varying temperatures. Cassava starch and potassium carbonate were used as local additives in the drilling fluid. 23 full factorial design experiments with variables such as temperature, starch and potash were conducted and corresponding viscosities were obtained.

Irawan [4] use local additives such as corn cobs and sugar cane wastes as viscosifier in drilling mud using Sarapar-147, a synthetic-based drilling mud formulation. It was discovered during this study that the plastic viscosity and yield point of the mud is directly proportional to the amount of the local additives added to the mud.

Barite is used in about 77% of mud preparation worldwide as a weighting agent for water-based and oil-based drilling fluids [5]. It is the most important weighting additive which makes it very expensive. Hence, the need for a research on local and cheaper alternatives.

Potash (Kaun) in Nigeria is edible and is defined as a rock salt and an ingredient "usually added to food especially pulses during cooking for faster tenderisation and to increase the viscosity in Okro and Ewedu sauce. Also used for emulsifying oil and water in some traditional soup"[6]

II. METHODOLOGY

- Simple water based mud was prepared using 22.5g of bentonite to 350ml of water.
- Physical properties of the mud were carried out to obtain the average density, pH, gel strength and viscosity at different speeds of viscometer.
- Varying weights of Tiro, Antimony sulphide, of 5g, 10g, 15g, 20g, 25g and 30g were added to fresh mud samples and the corresponding mud density, pH and viscosity were measured using mud balance, pH meter and viscometer respectively.
- Barite was used instead of Tiro as weighting additive and the same type of measurements were made also.
- Results obtained for the Tiro and that of barite were compared and plotted in Fig. 1-3.
- Various granulated weights of 2.5g, 5g, 7.5g and 10g of potash, as local thinners, were added to fresh samples of mud and corresponding properties of the mud were measured as in the case of weighting material.
- Various weights of 2.5g, 5g, 7.5g and 10g of lignosulphate, as thinners, were added to fresh samples of mud and corresponding mud properties were measured just like that of potash.
- Measured results were compared for the potash and the lignosuphate and plotted in Fig.4-6.

III. RESULTS

The keasure properties of the mud as weight of additives are added are presented in Table 1-6 below and the data is plotted in Fig.1-6. Table 1 gives the effect of increasing weight of Tiro and Barite on the density of the drilling mud while Table 2 gives the measured effect when the thinners, Potash and Lignosulphate, were used.

Tables 3-6 gives the effect of increasing weight of the additives, weighting and thinners, on the viscosity of the drilling mud using Vann Viscometer.

Table 1: Effect Of Weighting Additives On Mud Density And pH

WEIGHT OF ADDITIVE (g)	TIRO		BARITE	
	MUD WEIGHT (ppg)	PH	MUD WEIGHT (ppg)	PH
0	8.52	10.3	8.52	10.3
5	8.6	10.22	8.6	10.52
10	8.67	10.02	8.74	10.37
15	8.73	9.75	8.85	10.33
20	8.79	9.38	8.92	10.28
25	8.85	8.79	8.97	10.25
30	8.9	8.17	8.99	10.23

Table 2: Mud Density and pH Variation With Weight of Thinner Additives

	LIGNOSULPHATE		POTASH	
WEIGHT OF ADDITIVE (g)	MUD WEIGHT (ppg)	PH	MUD WEIGHT (ppg)	PH
0	8.52	10.3	8.52	10.3
2.5	8.35	9	8.35	9.91
5	8.15	9	8.15	9.9
7.5	8	9	7.9	9.89
10	7.9	9	6.95	9.87

Table 3: Viscosity And Gel Strength Reading For Tiro Additive

WEIGHT OF ADDITIVE(g)	600	300	GEL ST (10SEC)	GEL ST (10 MIN)	APPERENT VISCOSITY	PLASTIC VISCOSITY	YEILD POINT
0	13.8	10	3	12	6.9	5	5
5	15	10	4	19	7.5	5	5
10	15	10	4	19	7.5	5	5
15	15	10	4	19	7.5	5	5
20	14	8.5	1	16	7	5.5	3
25	10	5.5	1	11	5	4.5	1
30	9.5	5	0.5	10	4.75	4.5	0.5

Table 4: Viscosity And Gel Strength Reading For Barite Additive

WEIGHT OF ADDITIVE(g)	600	300	GEL ST(10SEC)	GEL ST(10 MIN)	APPERENT VISCOSITY	PLASTIC VISCOSITY	YEILD POINT
0	13.8	10	3	12	6.9	5	5
5	13.5	8.5	1	10	6.75	5	3.5
10	15.5	10.5	2.5	14	7.75	6	4.5
15	18.9	10.5	2.5	14	9.45	5	5.5
20	22	15	5	19	11	8	7
25	10.3	8	1	19	5.15	2.3	5.7
30	9	7.3	1	20	4.5	1.7	5.6

Table 5: Viscosity And Gel Strength Reading For Lignosulphate Additive

WEIGHT OF ADDITIVE(g)	600	300	GEL ST(10SEC)	GEL ST(10 MIN)	APP ERENT VISCOSITY	PLASTIC VISCOSITY	YEILD POINT
0	13.8	10	3	12	6.9	5	5
2.5	13.7	9.5	4	15	6.85	4.5	5
5	13.3	9	4	14	6.65	4.5	4.5
7.5	12.6	8.5	4	12	6.3	4	4.5
10	11.5	7	3	14	5.75	5	2

Table 6: Viscosity And Gel Strength Reading For Potash Additive

WEIGHT OF ADDITIVE(g)	600	300	GEL ST(10SEC)	GEL ST(10 MIN)	APPERENT VISCOSITY	PLASTIC VISCOSITY	TIELD POINT
0	13.8	10	12	0	6.9	5	5
2.5	13.5	9.8	12	1.25	6.75	5	4.8
5	12.5	9	7	2.5	6.25	5	4
7.5	11.7	8.5	8	3.75	5.85	5	3.5
10	11.1	8	10	5	5.55	5	3

Effect of weight of addtives on the mud weight is shown below in Fig.1 and it was discovered that Barite gave better weighting strenght than Tiro.

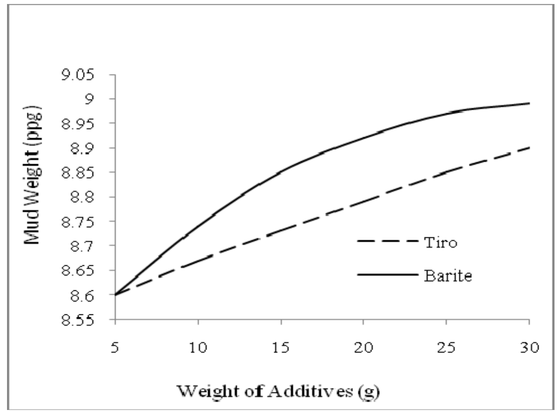

Figure 1. Graph of Mud Weight At Various Weight of Additives

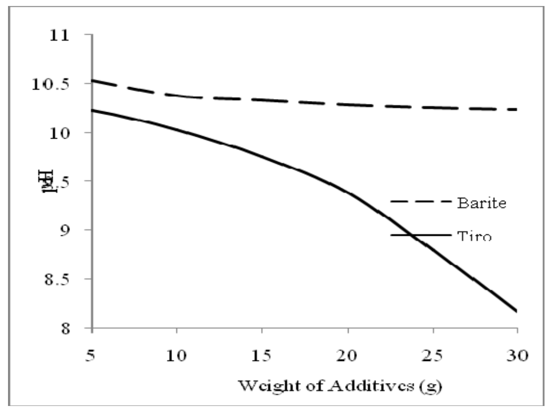

Figure 2. Graph of pH Variation With Weight of Additives

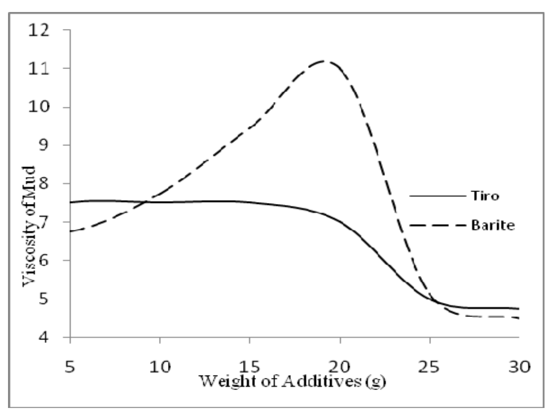

Figure 3. Graph of Viscosity Variation With Weight of Additives

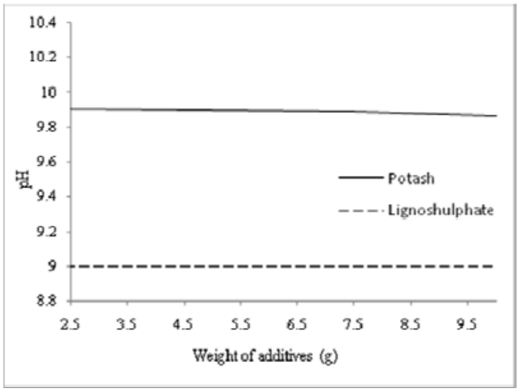

Figure 4. Graph of pH Variation With Weight of Thinners

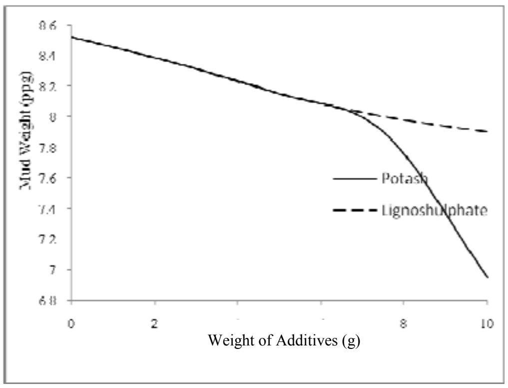

Figure 5. Graph of Mud Weight Variation With Weights of Thinners

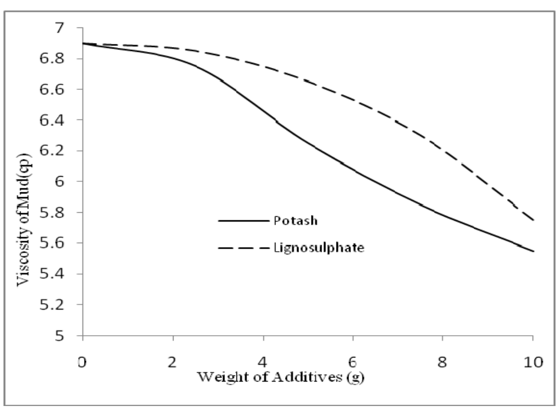

Figure 6. Graph of Viscosity Variation With Weight of Thinners.

IV. CONCLUSION

Effect of added weight of additive on the average pH of the mud is shown in Fig.2 above for weighting additives and Fig.4 for thinners. The desirable pH of the mud is between 5.0 and 8.0 in order not to have adverse effect on elastomers as stated by R & M Energy [8]. The Fig.2 shows that the Tiro caused a more rapid reduction in the highly basic mud than barite and bring the pH near the desired value.

There is tremendous increase in stability of bentonite clay in mud when the mud pH is increased from the normal range of 8.0-10.0 to range 10.5 to 11.5 [9] which tends to favour Barite over Tiro. Many users of pH as measurement of corrosion fatique of drill pipes and casing considered that a pH of less than 9.5 will shorten the corrosion fatique of drill stem [10] and this tends to favour Tiro over Barite.

Various equations that relate the weight of additives to that of the measured mud properties, using the trends of the various measured data, were obtained in the course of this research and are stated below as proposed model equations relating the mud density to that of weight of additives and also mud pH to the weight of additives.

The proposed equations are as follows:

i. MUD DENSITY

$$\ell_{mud} = -0.006m_b^2 + 0.0365m_b - 8.434 \quad (1)$$
$$\ell_{mud} = 0.012m_{tiro} - 8.5467 \quad (2)$$
$$\ell_{mud} = -0.0007m_p^4 + 0.0099m_p^3 - 0.047m_p^2 - 0.0017m_b + 8.52 \quad (3)$$
$$\ell_{mud} = 0.0022m_L^2 - 0.0853m_L + 8.5291 \quad (4)$$

Equations 1 to 4 relates the mass of weighting additive to the mud density where:

m_b= weight of barite added to the mud

m_{tiro}= weight of tiro added to the mud

m_p= weight of potash added to the mud

m_L= weight of lignosulphate added to the mud

ρ_{mud}= density of mud.

ii MUD pH EQUATIONS.

$$pH_{mud} = 0.00005m_b^2 - 0.0279m_b + 10.631 \quad (5)$$
$$pH_{mud} = -0.0023m_{tiro}^2 - 0.0014m_{tiro} + 10.29 \quad (6)$$

Where pH_{mud} is the measure pH of the mud.

For the thinners, potash and lignosulphate, the pH values of the mud remains constant after the first reduction due to addition of the thinner (Fig. 5). This implies that the two thinners have no effect on the pH values when the amount in mud is increased and hence can be used without having any adverse effect on the equipment.

The conclusion from this research is that Barite gave better performance on mud weight increase and pH maintenance than the corresponding weight of Tiro though the difference on the effect of the mud weight is not much but the effect on pH must be considered. Unfortunately, the barite gave unreliable influence on the viscosity of the mud while tiro gave better performance on mud density. Tiro is therefore recommended as the preferred weighting material but its use should be combined with the addition of another additive that will maintain the pH of the mud.

Moreover, both potash and lignosulphate proved to be very close substitute especially at low percentage reduction in mud weight. Potash gave a better result in pH maintenance than the lignosulphate and so is more reliable as a thinner.

Further work is recommended on the study of effect of high temperature and pressure on these materials to find out if the same observed effects will still be obtainable inside the well during drilling purpose.

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