UNPROCESSED OTA KAOLIN AS A WEIGHTING ADDITIVE IN DRILLING FLUID

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Abstract—Drilling fluid cost and effectiveness are two key factors in drilling fluid selection. Kaolinitic clay is of the family of bentonite and investigation was carried out to check the effect of partial replacement of expensive bentonite in drilling mud with cheap Nigerian kaolin. Two types of kaolin, kaolin1 and kaolin2, were sources in deep wells at Ota, Ogun state, Nigeria at depths between 100ft and 120feet. The two types of kaolin were used naturally in unprocessed state. It was discovered that the apparent and actual viscosities of the mud reduces significantly with increasing kaolin1 and kaolin2 content. Replacement of bentonite with kaolin1 resulted in 85.7% reduction in the mud viscosity while that of kaolin2 gave a corresponding 83.33% reduction. This is an indication that bentonite is more effective than the two kaolin as a viscosifier. The density of the mud slurry increased significantly with more kaolin1 and kaolin2 addition with a 25% and 27.25% increase respectively at 100% kaolin. The volume of each of the kaolin was doubled at total replacement of bentonite and an increase in weight was observed. This is an indication that the two types of kaolin are good weight additives. A replacement of 50% of the bentonite with any of the kaolin resulted into zero gel strength for the mud. The research indicated that the unprocessed kaolin serves as both colloidal and weighting additive but there will be need for a secondary viscosifier to be added if any of the kaolin is to be used for total replacement of bentonite in the mud. Moreover, a gelling additive must be added to the mud when the kaolin is to be used. Since the two types of kaolin tend to partially replace the bentonite and barite components of the water-based mud, their application in drilling mud is expected to reduce the cost of the mud as the additives are far cheaper than either bentonite or barite. This research is expected to extend to the second part which will involve the processing of the kaolin types and their application on the drilling mud properties and also investigate the possibility of enhanced gelling properties of the kaolin.

Keywords-component; Ota kaolin, drilling mud, viscosity, weighting additive

I. INTRODUCTION

Kaolin is an inert material and a hydrous form of aluminium silicate. Commercial deposits of kaolin exist near the towns of Ilorin, Dagbalodo, Echiwada, Tsaragi, Otte and Isanlu-Isin in Kwara State (*TradeInvest Nigeria* 20 January, 2011). Presently, Kwara State Government, Nigeria, is making strong effort for the exploitation of the material and this is expected to be of immense economic value to the major industries in Nigeria especially the oil industry but this is on the condition that it has useful application in the oil industry. Though, the Kwara deposit is proven, the Ogun State deposit is vast and unproven. Boreholes located over a kilometer apart at Ota, Ogun State, Nigeria has deposit of the same kaolin between 100 to 130 feet deep. Hence, it is a very large deposit. United States Geological Survey (USGS) gave recorded kaolin production in Nigeria at 100,000 metric tonnes as at 2007. Studies show that Nigeria Kaolin is of high alumina content, up to 33 - 42 wt% (Edomwonyi-Otu, 2010) and this is responsible for the dirty white to pink colouration of the kaolin.

Endell (1950) observed that the drilling mud that was used in the North-western part of Germany, as a drilling mud, contain kaolin and mica-like clay mineral as part of the composition. This is a good indication that kaolin can serve as an additive in a drilling mud formulation.

Larren (1952) in his research concluded that kaolinitic clay cannot be used in its pure unprocessed form. He also discovered that when sodium hydroxide is present in drilling fluid containing kaolin content, it causes reduction in the density of the mud but when the clay content is bentonite, it causes the density of the mud to increase. This research shows that kaolin can be used as weight additive though as a thinner and not a weighting material when sodium hydroxide is added. This is also a good indication that kaolin is applicable in drilling mud formulation.

Adebayo (2011) researched into application of locally-derived additives as weighting materials in drilling mid. Tiro, a local Antimony compound, and potash were used in the research and it was concluded that local materials can compete favourably with imported processed materials as drilling mud additives even in their unprocessed form.

This research focused on the application of the raw and unprocessed Ota-Nigeria kaolin as an additive in drilling mud and as a close substitute to expensive and imported bentonite and barite. This will enable another application for the imported bentonite and barite and makes the price relatively cheaper for other sectors using them.

II. PROCEDURE

Simple water based mud samples were prepared to study the effect of the two type of unprocessed kaolin obtained inside boreholes at Ota, Ogun State, Nigeria. Kaolin1 was dirty white in colour while Kaolin2 was deep pink in colouration. Both kaolin types were unprocessed since the study involves using cheapest component for drilling mud additives in Nigeria setting. The mud composition used is as stated in tables 1 and 2 below. This involves partial to total replacement of the bentonite component by the unprocessed kaolin. This process was followed because kaolin and bentonite are of the same clay family and was expected to be close substitutes.

Rheological tests of the drilling mud were carried out which include mud weight measurements at varying bentonite-kaolin fractions and also measurement of the mud viscosities and gel strengths of the various mud samples. Below in Table 1 and 2 is the composition of the kaolin 1 and 2 and bentonite in the prepared drilling mud.

Table 1: Fraction of Kaolin1-Bentonite In Mud

Sample	% Kaolin1 weight composition	Kaolin1-Bentonite Ratio
A1	100	100% Kaolin 1 (double weight)
A2	100	100% Kaolin 1
A3	75	25%Bentonite, 75% Kaolin1
A4	50	50% Bentonite, 50% Kaolin1
A5	25	75% Bentonite, 25% Kaolin1
A6	0	100 % bentonite

Table 2: Fraction of Kaolin2-Bentonite In Mud

Sample	% Kaolin2 weight composition	Kaolin1-Bentonite Ratio
B1	100	100% Kaolin 2 (double weight)
B2	100	100% Kaolin 2
B3	75	25% Bentonite, 75% Kaolin 2
B4	50	50% Bentonite, 50% Kaolin 2
B5	25	75% Bentonite, 25% Kaolin 2
B6	0	100 % bentonite

III. RESULTS

The variation in the mud density with varying ratio of kaolin and bentonite were investigated and the results of the mud density variation are stated in Table 3 for kaolin1 type and Table 4 for kaolin2. The density tends to increase with increasing kaolin1 or kaolin2 percentage in the mud.

Table 3: Density Variation With Change in Percentage of Kaolin1 In Mud.

Sample	Clay composition In Mud	Density
A1	100% Kaolin 1 (double weight)	8.45
A2	100% Kaolin1	8.35
A3	25%Bentonite + 75% Kaolin1	8.3
A4	50% Bentonite + 50% Kaolin1	8
A5	75% Bentonite + 25% Kaolin1	7.45
A6	100 % bentonite	6.68

Table 4: Density Variation With Change in Percentage of Kaolin2 In Mud

Sample	Clay composition In Mud	Density
B1	100% Kaolin 2 (double weight)	8.65
B2	100% Kaolin 2	8.5
B3	25% Bentonite + 75% Kaolin 2	8.4
B4	50% Bentonite + 50% Kaolin 2	8.2
B5	75% Bentonite + 25% Kaolin 2	7.5
B6	100 % bentonite	6.68

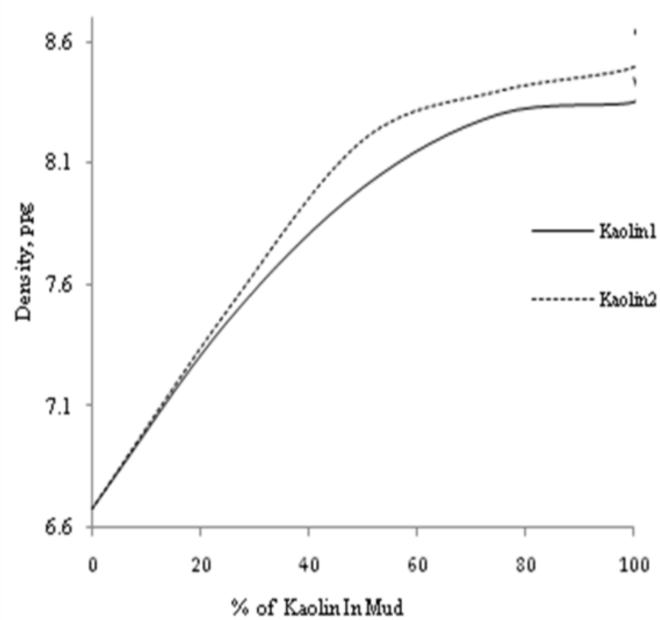

Fig.3: Density Variation With Kaolin1 or kaolin2 In Mud

TABLE 5: VISCOSITY READING FOR KAOLIN 1- AND KAOLIN2-BENOTNITE MIXTURES

	600RPM Reading	300RPM Reading	Apparent Viscosity
100% kaolin1(double wt)	5	3	2.5
100% Kaolin1	3	2	1.5
75% Kaolin1	5	3	2.5
50% Kaolin1	8	4	4
25% Kaolin1	13	8	6.5
100 % bentonite	21	12	10.5
100% Kaolin2 (double wt)	3	2	1.5
100% Kaolin2	3.5	2	1.75
75% Kaolin2	4.5	2.5	2.25
50% Kaolin2	7.5	4	3.75
25% Kaolin2	14	9	7
100 % bentonite	21	12	10.5

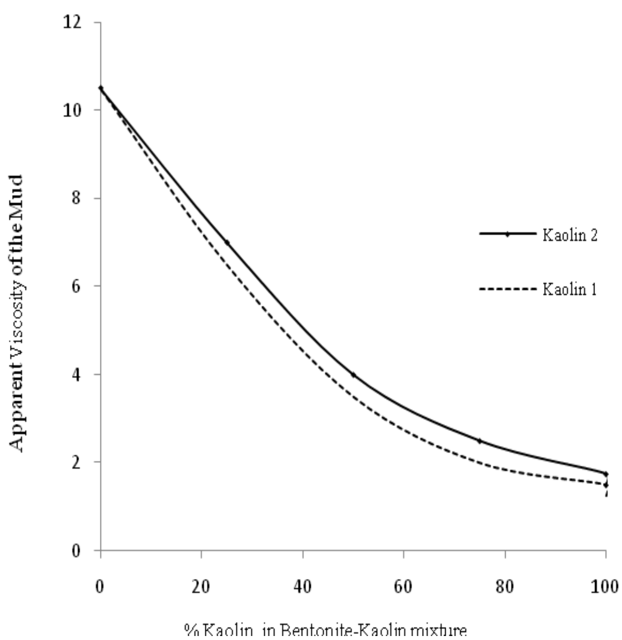

Fig.4: Mud Apparent Viscosity versus Bentonite-Kaolin Ratio

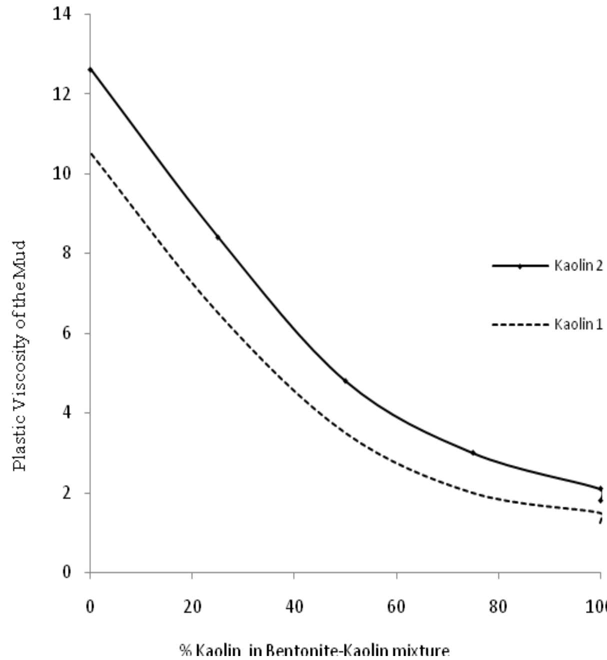

Fig.5: Mud Caclculated Viscosity Versus Bentonite-Kaolin Ratio

TABLE 6: GEL STRENGTH FOR KAOLIN 1-BENOTNITE MIXTURE

	Initial Gel Strength	Maximum Gel Strength
200% Kaolin 1	0	0
0% Bentonite, 100% Kaolin 1	0	0
25%Bentonite, 75% Kaolin 1	0	0
50% Bentonite, 50% Kaolin 1	0.5	0.5
75% Bentonite, 25% Kaolin 1	1.5	7
100 % bentonite	4	10

TABLE 7: GEL STRENGTH FOR KAOLIN2-BENTONITE MIXTURE

	Initial Gel Strength	Maximum Gel Strength
200% Kaolin 2	0	0
0% Bentonite, 100% Kaolin 2	0	0
25% Bentonite, 75% Kaolin 2	0	0
50% Bentonite, 50% Kaolin 2	0	0
75% Bentonite, 25% Kaolin 2	1	9
100 % bentonite	4	10

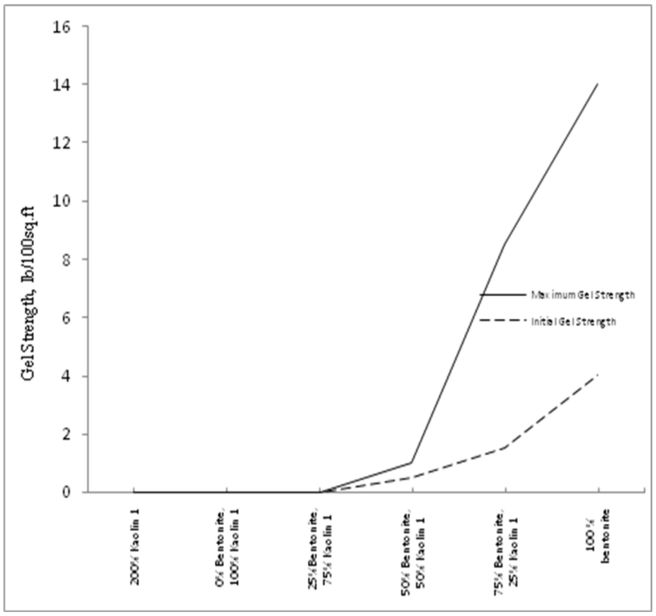

Figure 6: GEL STRENGTH FOR KAOLIN1-BENTONITE MIXTURE

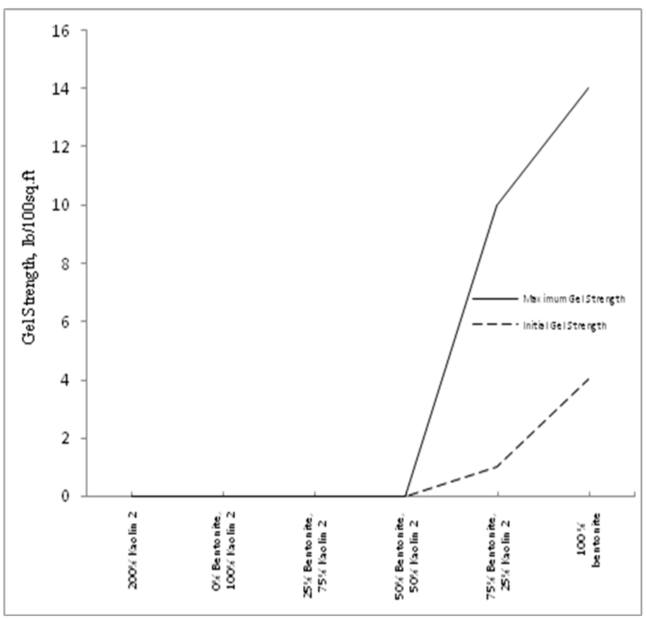

Figure 7: GEL STRENGTH FOR KAOLIN2-BENTONITE MIXTURE

IV. CONCLUSION

From the results obtained it was discovered that the mud density increased by 85.7% when the kaolin1 was used to totally replaced the bentonite in the mud. The weight of the kaolin1 was doubled to confirm this and the density further increased from 8.35ppg to 8.45ppg as stated in Table 3.

Table 4 shows that the total replacement of bentonite content of the mud by kaolin2 gave 83.33% increase in the mud density and when the weight of the kaolin was also double there was further 0.15ppg increase in the mud density. This is in line with the fact the colouration of the Kaolin1 and Kaolin2 is due to the iron content in the mud as the Kaolin were used in their unprocessed stages for minimal drilling mud cost.

Graphs relating the effect of kaolin1 and kaolin2 to bentonite ratio on the viscosity of the mud is as shown in Fig.4 and Fig.5 above. It showed that the replacement of bentonite with any of the kaolin caused a reduction in the viscosity of the mud.

The Gel Strength of the mud was also affected with addition of kaolin 1- and 2- to the mud as indicated in Tables 6 and 7 and graphs 6 and 7 above. This implies that there is need for addition of gelling additives to the mud in order to minimize the effect of the kaolin when over 50% of required bentonite is replaced with kaolin.

REFERENCES

1. Trade Invest Nigeria, Jan. 20, 2011, "*Opportunity to mine and process kaolin*" http://www.tradeinvestnigeria.com /investment _opportunities/710535.htm
2. Lawrence Chukwuka Edomwonyi-Otu, Benjamin Olufemi Aderemi, 2011, Comparative Study of Alum Production from Nigerian Kaolin Clay, *Materials Science & Technology Conference & Exhibition,* October 16-20, Columbus, Ohio, USA.
3. United States Geological Survey (USGS) Minerals Resources Program (http://minerals.usgs.gov/)
4. Adam T. Bourgoyne Jr., Martin E. Chenevert, Keith K. Millheim and F. S. Young Jr., *Applied Drilling Engineering*, Society of Petroleum Engineers Textbook Series, Vol.2, Richardson, TX, USA.
5 Bndell, J., 1950, *Tone in der Erdölindùstrie*: Erdö1 und Kohle, V.3, pp. 105-109.
6 Delmar H. Larsen, 1952, *Part VII: Clay Technology in the Petroleum Industry; Use of Clay in Drilling Fluids* Clays and Clay Minerals vol.1 : 269-281
7 Adebayo, Thomas A. and Imokhe Omoleghon, 2011, *Tiro (Antimony-Sulphide) And Potash As Local Substitutes To Imported Barite And Lignosulphate In Drilling Mud Weighting Additives*, International Journal of Engineering and Sciences, Vol.11, issue 3, June 10, 2011, pp138-142.

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