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Experimental Investigation Of The Use Of Local Clay (Abbi, Delta State, Nigeria) As A Substitute For Foreign Imported Bentonite Clay In The Formulation Of Aqua Base Drilling Fluid.

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ABSTRACT : Nigeria is a major oil producer and therefore embarks on substantial drilling activities. The drilling activities for the development of petroleum and underground natural resources are indeed consuming large quantities of clay for drilling mud preparations, of which are being imported. In this research work, the rheological formulation of our locally sourced Bentonite clay in substitute for the imported foreign Bentonite clay was carried out by the comparative analysis of the parameters of the local mud with the stipulated API standard values of imported mud to ascertain the level of compliance in drilling operation. At the end of this laboratory analysis, it was obvious that most of the properties of the local clay such as: mud weight, gel strength, sand content, consistency index and power law index meet the standard specification of imported foreign drilling mud, while other rheological properties and mud pH needed a little treatment with additives to improve it properties to meet that of a foreign imported mud.

Keywords: Bentonite, Gel strength, Mud weight, Power law index, Bentonite

INTRODUCTION

Nigeria's economy is largely based on its oil resources and she is the largest oil producer in sub-Saharan Africa. In view of the fact that hydrocarbon and water beneath the ground could only be exploited through drilling wells, the petroleum industry especially has continued to make increasing use of clay which is the main constituent of drilling fluids. Research over the past several years has clearly shown that drilling activities in the petroleum and ground-water development industries in Nigeria have consumed, and are still consuming, large amounts of clays for drilling muds, all of which are imported despite the presence of large reserves of clay in Nigeria (Omole et al., 1989). Prior to the government's initiative to develop local content, the cost of importation of bentonite for drilling activities in Nigeria runs to millions of dollar annually which has been detrimental to the economy of the country considering that about 5 to 15% of the cost of drilling a well which ranges between $1 million to $100 million accounts for drilling fluids (Ben Bloys et al., 1994; http://www.wikipedia.com). Therefore, it is imperative to locally outsource these clay materials in order to conserve foreign exchange, create employment and to enhance Nigerian content development in the drilling component of oil and gas industry.

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It was reported by Emofurieta (2010) at the international conference on "Modern Mining Processing" that Nigeria bentonite proven reserve has risen above four billion metric tons. Thus, its abundant reserve cannot be ignored because of increased revenue it will generate when fully exploited and more so as means of developing economy of the country through creation of more industries which will consequently lead to local skill transfer and man power development. "The selection of the most suitable mud type and mud properties, and the efficient engineering support whilst drilling will help to ensure a safe and successful operation. Any problem where the mud fails to meet its requirements can not only prove extremely costly in materials and time, but also jeopardize the successful completion of the well and may even result in major problems such as kicks or blowouts" (Rabia, 2002). Hence it is necessary to critically examine the suitability of Nigerian clays in regards to their rheological properties. The objectives of this study are to investigate the rheological properties of Abbi clay beneficiated with with 1.0g of potash and compare it with imported Bentonite using the API (American Petroleum Institute) specifications.

3.0 MATERIAL AND METHODS

3.1. Preparation of Mud Sample

The clay sample for this work was collected from Abbi town which is located in Ndokwa West Local Government Area of Delta State, Nigeria. It is located within Latitude 6.45^{0}E and Longitude 5.30^{0}N

API RP-13B Standard procedures were employed throughout the laboratory work to determine rheological and fluid loss properties. All the sample mud are based on the formulation of 350 ml of fluid that contains only fresh water

The clay samples were prepared accordingly with the addition of 350ml of water as indicated below:

1. A high concentration mud contains 24.5g of clay plus 350ml of water
2. Medium concentration mud contains 21.0g of clay plus 350ml of water
3. Low concentration mud contains 17.5g of clay plus 350ml of water

3.2. Laboratory procedure

The clay sample collected from Abbi was dried under moderate temperature spread out in a plastic tray in a drying oven. The dried clay sample was then subjected to pulverization by pounding it in a mortal. The pulverized clay sample was sieved to obtained fine powdered clay particles. The sieved clay sample was collected in a beaker and labeled appropriately using a masking tape. Then 17.5g, 21.0g and 24.5g of the fine clay sample was weighed using a spatula into separate mixer cups with the help of weighing balance and labeled appropriately. Then 350ml of distilled water is measured using a 500ml measuring cylinder into the already weighed clay samples. The mixture of the clay and water was stirred with the aid of multi-beach mixer for (2-5) minutes to obtain homogeneous mixture. The homogeneous mixture obtained was aged for 24 hours for proper hydration. After 24 hours of aging, the mud was re-stirred to re-agitate the mud for characterization.

3.2.1 Determination of viscosity

This test was done to obtain the marsh funnel viscosity of the different mud samples using a marsh funnel viscometer and a graduated cup using OFITE 900 MODEL viscometer the following **materials:** Freshly prepared sample, masking tape, recording book and biro

Procedure

The cord of the viscometer was connected to the power source and the instrument switched on. The freshly prepared was poured into the sample cup of the viscometer

The ENTER button pressed and the rotor was allowed to rotate for few seconds for stabilization. The rotor sleeve was then immense until the mud touched the scribed line of the rotor sleeve. The mud button was pressed and the viscometer automatically carried out the measurement of the θ600rpm and θ300rpm. The equipment calculated the 10seconds and 10minutes gel strength

NOTE: It was observed that at the end of the 10minutes, the machine displayed the value of plastic viscosity (PV), and the yield point (YP) along with 10seconds and 10minutes gel strength was displayed. These values were recorded in the table of result respectively.

3.2.3. pH determination

The degree of acidity or alkalinity of mud is indicated by the hydrogen ion concentration, which is commonly expressed in terms of PH. A neutral mud has a PH of 7.0. An alkaline mud has PH readings ranging from just above 7 for slight alkalinity, to 14 for the strongest alkalinity, Acid mud range from just below 7 for slight acidity, to less than I for the strongest acidity.

pH measurements aid in determining the need for chemical control of the mud, and indicates the presence of contaminates such as cement and gypsum. The appropriate PH of drilling mud sample was determine using: Multi-Hamilton beach mixer and materials like**;** Freshly prepared sample, phydrion dispenser paper, masking tape, recording book and biro

Procedure

The freshly prepared mud was re-stirred to obtain homogeneous mixture. About one inch strip of the phydrion dispenser paper was removed and placed gently on the surface of the mud. Sufficient time was allowed to elapsed (about few seconds) for the paper to soak up filtrate and change colour. 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 in the table of result respectively. The procedure was repeated for other concentration of the mud.

3.2.4 Determination of The 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 is done to determine whether the prepared local mud samples possess API minimum required weight for oil well drilling by using Multi-Hamilton beach mixer, Bariod mud balance with the following materials**:** Freshly prepared sample, rag, water, masking tape, recording book and biro.

Procedure

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. The lid was placed on the cup and set it firmly but slowly with twisting motion. It was ensured some mud spilled on the outside of the cup through the vent.

Then the reading of the mud balance scale is taken and recorded properly against the mud type. The mud cup is then emptied, washed, dried and properly kept away for future use.

3.2.5 Determination of Sand Content

By definition, solid particles larger than 74 micros (200 meshes) are classified as API sand. (A micron is one (million) inch of a meter there are about 25, 400 microns to an inch) regular determination of the sand content of drilling mud is necessary because these particles can be highly abrasive, and can cause excessive wear of pump parts, drill bits, and pipe connections, excessive sand may also result in the deposition of a thick filter cake on the walls of the hole, or it may settle in the hole around the tools when circulation is temporarily halted, interfering with the operation of drilling tools of settling casing. The sand content test for set is used in the test for sand content determination using Bariod sand content set and freshly prepared sample, rag, water, and spatula

Procedure

The Baroid sand content tube was filled to mark "MUD TO HERE" with the formulated mud sample. Water was then added to the mark "WATER TO HERE". Then the tube was covered with thumb and shaken vigorously. The mixture of the mud and water was poured out through the screen, the held back sand were carefully washed to ensure that the mud sample was out in a gently running tap. The sand left in the screen was then washed back into the tube through a funnel that is fitted over and inverted slowly into the mouth of the tube. The quantity of the sand that settle in the calibrated tube was then read and recorded as the sand content of the mud in percentage by the volume of mud.

3.2.6 API Standard Tests and Analysis Values of Drilling Mud

When the mud is characterized or tested, the figures recorded down are compared with known standard values. The American Petroleum Institute (API) standard specification for all the montmorillonite clay family as contained in API practices 13A section 5 are as follows:

Table 3.0: API standard numerical value requirement for drilling fluids

Drilling Fluid Property	Numerical Value Requirement
Mud density (lb/gal)	8.65-9.60
Viscometer dial reading @600rpm	30cp
Plastic viscosity (cp)	8 – 10
Yield point (Ib/100ft2)	3 x plastic viscosity
Fluid loss (Water)	15.0ml maximum
pH level	9.5min–12.5max
Sand content	(1-2)% maximum
Screen analysis	4 (maximum)
Moisture content	10% (maximum)
Ca 2+ (ppm)	2.50 (maximum)
Marsh funnel viscosity	52 – 56 sec/q+
Mud yield (bbi/ton)	91 (maximum)
API filtrate (ml)	30 (minimum)
Montmorillonite	70 – 130
Vermiculite	100 – 200
Illite	10 – 40
Kadinite	3 – 15
Chlorite	10 – 40
Marsh funnel viscosity for water	26 sec/q+ ± 0
N-Factor (power law index)	1 (maximum)
Yp/pv ratio	3.0 (maximum)

4.0 RESULT PRESENTATION/ ANALYSIS

Table 4.0: Result of analysis of local clay sample after 24 hours of aging

Clay conc.	17.5	21.5	24.5
Mud weight	8.6	8.6	8.6
Mud Ph	6.0	6.0	6.0
Viscometer reading @600rpm	2.4	2.6	2.7
Viscometer reading @300 rpm	1.7	2.0	2.0
Mud sand % volume	0.25	0.25	0.38
Mud PV	0.7	0.6	0.7
Mud AV	8.9	10.6	15.7
Mud gel strength@ 10 secs	0.00	0.80	0.90
Mud gel strength@ 10 min	0.00	0.80	1.00
Mud YP	1.0	1.4	1.3
"n" factor	0.50	0.38	0.43
"k" factor	1.24	0.94	0.54

Table 4.1: Result of analysis of Bentonite mud after 24 hours of aging

Clay conc.	17.5	21.5	24.5

Mud weight	8.7	8.7	8.7
Mud Ph	9.0	9.0	9.0
Viscometer reading @600rpm	17.70	21.21	31.40
Viscometer reading @300 rpm	10.20	11.60	18.50
Mud sand % volume	0.3	0.3	0.3
Mud PV	7.5	9.5	12.9
Mud AV	8.9	10.6	15.7
Mud gel strength@ 10 secs	0.1	0.2	0.7
Mud gel strength@ 10 min	1.50	5.10	12.10
Mud YP	2.7	2.1	5.6
"n" factor	0.79	0.56	1.39
"k" factor	0.65	3.27	1.39

Table 4.2: Comparism of properties of local clay with foreign Bentonite clay @17.5g concentration

Properties	Local clay	Foreign clay
Mud weight	8.6	8.7
Mud Ph	6.0	9.0
Viscometer reading @600rpm	2.4	17.70
Viscometer reading @300 rpm	1.7	10.20
Mud sand % volume	0.25	0.3
Mud PV	0.7	7.5
Mud AV	8.9	8.9
Mud gel strength@ 10 secs	0.00	0.1
Mud gel strength@ 10 mins	0.00	1.50
Mud YP	1.0	2.7
"n" factor	0.50	0.79
"k" factor	1.24	0.65

Table 4.3: Comparism of properties of local clay with foreign Bentonite clay @21.0 g concentration

Properties	Local clay	Foreign clay
Mud weight	8.6	8.7
Mud Ph	6.0	9.0
Viscometer reading @600rpm	2.6	21.21
Viscometer reading @300 rpm	2.0	11.60
Mud sand % volume	0.25	0.3
Mud PV	0.6	9.5
Mud AV	10.6	10.6
Mud gel strength@ 10 secs	0.80	0.2
Mud gel strength@ 10 mins	0.80	5.10
Mud YP	1.4	2.1
"n" factor	0.38	0.56
"k" factor	0.94	3.27

Table 4.4: Comparism of properties of local clay with foreign Bentonite clay @24.5 g concentration

Properties	Local clay	Foreign clay
Mud weight	8.6	8.7
Mud Ph	6.0	9.0
Viscometer reading @600rpm	2.7	31.40
Viscometer reading @300 rpm	2.0	18.50
Mud sand % volume	0.38	0.3
Mud PV	0.7	12.9
Mud AV	15.7	15.7

Mud gel strength@ 10 secs	0.90	0.7
Mud gel strength@ 10 mins	1.00	12.10
Mud YP	1.3	5.6
"n" factor	0.43	1.39
"k" factor	0.54	1.39

5.0 DISCUSSION OF RESULTS

Mud weight analysis from table 4.2, table 4.3 and table 4.4 shows that at concentration of 17.5g, 21.0g and 24.5g the local cay mud weight was 8.6g, 8.6g and 8.6 g whereas the value for foreign mud was 8.7g,8.7g and 8.7g respectively. This shows that the local clay can serve as a substitute for foreign clay in term of mud weight

For Ph analysis, table 4.2, table 4.3 and table 4.4 show that at concentration of 17.5g, 21.0g and 24.5g the local clay Ph value was 6.0, 6.0 and 6.0 whereas the value for foreign mud was 9.0, 9.0 and 9.0 respectively. This implies that the local clay needs a little additive in other to meet Ph standard of foreign mud.

For viscosity analysis, table 4.2, table 4.3 and table 4.4 show that at concentration of 17.5g, 21.0g and 24.5g the local clay viscometer reading @600 rpm was 2.4 cp, 2.6cp and 2.7cp, @300 rpm the values are 1.7cp, 2.0cp and 2.0cp whereas for foreign mud it was 17.70 cp, 21.21 cp and 31.40cp and 10.20 cp, 11.60cp and 18.50 cp respectively. This shows that the local mud need a little beneficiation to raise its viscosity.

For Mud gel strength analysis, table 4.2, table 4.3 and table 4.4 show that at concentration of 17.5g, 21.0g and 24.5g the local clay gel strenght readings @10 secs were 0.1, 0.2, 0.7, @10 mins the values are 1.5,5.1, 12.10 whereas for foreign mud it was 0.1, 0.2, 0.7 and 1.50, 5.10,12.10 respectively. This implies that the local clay properties really meet the standard of foreign clay in term of gel strenght. It was also seen that Mud AV and PV analysis shows similar trend and need no additives whereas mud YP, n and k factors need alittle adjustment

6.0 CONCLUSION

From the above analysis, it was obvious that most of the properties of the local clay such as: mud weight, gel strength, sand content, consistency index and power law index meet the standard specification of foreign drilling mud, while other rheological properties and mud Ph needed a little treatment with additives to improve it properties to meet that of a foreign mud.

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