PRODUCTION OF DRILLING MUD FROM AFUZE AND MAIDUGURI CLAYS

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ABSTRACT

This research is aimed at testing the suitability of Nigerian montmorillonitic clays for Bentonite as well as finds a way of upgrading the clay if there are some properties that are lacking. American Petroleum Institution (API) Recommended Practice 13 A was followed in the test procedure to determine the plastic viscosity, fluid loss, residue weight i.e. percentage greater than 75 micrometers and moisture content of the clay samples. It was discovered that of these four properties, only moisture content was in the range of the required specification. Plastic viscosities of the clays were very low and fluid losses were excessively high. Also, residue weight, i.e. percentage greater than 75 micrometer was also greater than the required specification. Attempt was made to upgrade the clays in terms of adding some biopolymers. The research was successful in that at the end, plastic viscosity and fluid loss were adjusted to meet the API specifications as shown in samples A6 and B6 in table 7. The samples were used to prepare drilling mud.

INTRODUCTION

Nigeria as one of the largest oil producing countries in the world makes use of very large reserve of bentonite (clay) and barite for the production of drilling mud. Drilling mud became known with the introduction of rotary drilling (modern drilling operation) in 1900. The dynamic development of drilling fluid although began in1930 but it has been on ever since. The term drilling mud is a fluid/liquid circulated through the well bore during drilling and work operation. The mud used is usually of three phase mixtures namely; liquid, reactive solid and inert solids.

Drilling mud is a mixture of montmorillonitic clays, water, barite and a few additives. It is on record that between 1960 and 1964 bentonite clays from the then Bendel (now Edo) were employed by Shell Dark Company for drilling operations.

In 1973, Afuze (a town in the then Bendel now Edo State) clay was used during drilling operations for coal by the defunct Nigerian Steel Development Authority. The development and exploration of abundant clay deposit in Nigeria awaits private investment. The proper development and exploitation of our local Bentonite would go a long way in aiding the industrial development of Nigeria and provide numerous employment opportunities for her citizens.

The reliance of developing countries like Nigeria on developed countries for solid minerals has led to a fall in industrial development and depletion of external reserves. Attempt to reverse this is the foundation on which this research work is built. Despite the knowledge of the availability of abundant reserve of solid minerals in Nigeria, she has continued to be a major importer of industrial minerals.

This research work is on the production of drilling mud from local clays. Drilling is a process in which a machine or tool is used for boring holes. For this work, drilling is a process in which a hole is made in the ground to allow subsurface hydrocarbons to flow to the surface. Drilling mud is one of the most important materials for any drilling operation. The mud is carefully formulated to ensure correct weight and viscosity characteristics to perform its required tasks. The wastes generated during drilling are removed to make the holes and the fluid is used to lift the cuttings after which other materials (such as Barium Carbonate, Sodium bi-carbonate, Sodium Carbonate etc) are added to the fluid to change its properties to make it more suitable for use and to condition the hole. During drilling the mud is left in the borehole to prevent excessive fluid flow into the well.

Functions of Drilling Muds/Fluids

In the early days of rotary drilling, the primary function of drilling fluid was to bring the cuttings from the bottom of the hole to the surface (Dawodu, 2003). Today it is recognized that drilling fluids have at least eleven functions. These functions include;

i. To remove cuttings from the bottom of the hole and carry them to the surface.
ii. To cool and lubricate the bit and drill pipe/string.
iii. To coat the hole with a low with a low permeability filter cake.
iv. To control sub-surface pressure.
v. To hold cutting and weight material in suspension when circulation is interrupted.
vi. To release sand and cutting at the surface.
vii. To reduce to a minimum any adverse effects upon the formation adjacent to the well base.

Basic Mud Properties

The effectiveness of a drilling mud in performing its several functions is directly related to density, viscosity, gel strength and filtration. These properties are associated with colloidal or clay fraction of the mud which can be altered by treatment.

Rheology

Rheology is a broad name that denotes the study of the deformation of materials including flow. In oil field terminologies, the flow properties and the word viscosity are the expression generally used to describe the behavior of drilling mud in motion. A high viscosity fluid is desirable to carry cuttings to the surface and suspended weighting agents in the mud. However if viscosity is too high friction may impede the circulation of the mud causing excessive pump pressure, decrease drilling rates and hamper solid removal.

Gel strength

It is a measure of the structure developed as a result of the alteration between particles when the mud is stationary. Gel properties of the mud determines the swabbing effect on pulling the drill pipe, pressure required to break circulatory, ease of release of gas and settling the gas particles in the pit.

Density

The density helps determine the magnitude of pressure exerted by the fluid against the borehole walls and on the formation fluid. It also determines the hydrostatic pressures which the mud will exert at any particular depth and has a significant effect on the rate of rock disintegration thereby preventing the bore hole wall from caving in and to keep formation fluid from entering the well bore.

Fluid loss

Water is continually lost from drill mud to permeable formations during drilling operations. A permeable formation such as sand acts as a strainer holding back the solids in the mud while permitting the water to pass into the pore spaces. These solids are deposited on the face of the sand in the form of a coat or filter cake. The aim of a good drilling mud is to create a low permeability filter cake to seal between the well bore and the formation.

Solids/Sand content

Along side-undissolved lumps of clay rocks the mud also carries some particles of hard abrasive rocks that are liable to cause intensive wear of the equipment. The sand content of the fluid that is the totality of the hard rock particles and of undisclosed lumps of clay is determined by means of a settler. Sand content does not usually exceed 1-2%.

Table 1: Locations of bentonite clays in Nigeria.

S/N	LOCATION	GEOLOGICAL FORMATION	ESTIMATED RESERVE (MILLION TONNES)	%MONTMO RILLONITE
1	Borno/Yobe. Damboa km 14 from Maiduguri. Damboa -Biu road.	Cotton soil. Weathered products of quaternary – tertiary clays.	700,000	70 – 80%
1b	Dikwa – Ngala areas of Borno States.	Chad basin		70 – 80%
2	Taraba – Adamawa, Mayo - Balewa	River channel	Not yet quantified	
3	Abia, Bende, Umuahia	Bende – Ameki formation and Imo shales	Not yet quantified	40 – 60%
4	Abia, Ishiagu	Weathered products of the shales of Asu River	,,	80%
5	Imo Uturu	Bende – Ameki formation and Imo shales	,,	40 – 60 %
6	Anambra /Awka	Imo shales	,,	30 – 40%
7	Edo – Afuze & Ekpoma	Benin formations	,,	70 – 80%

Source: Dawodu, 2003.

EXPERIMENTAL

The analysis involved determining the physicochemical properties of the clay in other to compare with the required specifications given by the American Petroleum Institute (API). Various attempts were made for the beneficiation process. The experiment was divided into three parts namely: testing the suitability of Nigerians montmorillonitic clays for bentonite; chemical-mechanical beneficiation, that is a reasonable control of the chemical and mineralogical properties of clay which was done by adding additives (PacR and Na_2CO_3) to the samples; and using the upgraded bentonite for mud formulation. Plastic viscosities and yield points of the clays were determined by the use of viscometer. Filtrate volumes were measured by the use of filter press, moisture content was determined by the use of oven, sand content was determined using the sand content set and Calcium ions and other ion contents were determined using the titrimetric method. Mud was prepared using a multimixer model 9B x impeller blade.

Table 2: Samples and Locations of samples

SAMPLES	LOCATION
A	Afuze (Edo State) Clay.
B	Maiduguri (Borno State) Clay.

Table 3 Specification for drilling grade bentonite

REQUIREMENT	SPECIFICATION
SUSPENSION PROPERTIES	
Viscometer dial reading at 600rpm	30minimum
Yield point/ plastic viscosity Ratio	3maximum
Filtrate Volume	15cm^3 maximum
Residue >75μm	4.0 wt % maximum
Moisture	10.0 wt % maximum

RESULTS

The results of the experiments are presented in tables 4 to 9 below

Table 4: Test of Local Clays.

	SAMPLE PROPERTIES		
SAMPLE NUMBERS	A	B	SPECIFICATION
Moisture %	3.23	3.95	10 max
Screen analysis	6.9	7.5	4 max
BENTONITE PROPERTIES Bentonite 22.5g /350ml H_20			
600 rpm Reading	9	10	30 min
300 rpm Reading	5	7	
Plastic viscosity, Cp	4	3	
Yield point	1	4	
10 secs Gel lb /100sqft	0	0	
10 min Gel lb/100 sqft	1	1	
pH	8	8	9 – 11
Filtrate volume	80	88	15max
YP/PV Ratio	0.25	1.33	3 max
Ca^{++} (ppm)	36	40	250 max
% Sand content	Trace	Trace	Trace

Table 5: Beneficiation of Samples 'A' AND 'B'

SAMPLES	ADDITIVE (s) ADDED
A_1	22.5g Clay + 0.25g PacR
B_1	22.5g Clay + 0.25g PacR
A_2	22.5g Clay + 0.50g PacR
B_2	22.5g Clay + 0.50g PacR
A_3	22.5g Clay + 0.75g PacR
B_3	22.5g Clay + 0.75g PacR
A_4	22.5g Clay + 1.00g PacR
B_4	22.5g Clay + 1.00g PacR
A_5	22.5g Clay + 1.25g PacR
B_5	22.5g Clay + 1.25g PacR
A_6	22.5g Clay + 1.50g PacR
B_6	22.5g Clay + 1.50g PacR
A_7	22.5g Clay + 1.50g PacR +1g Na_2CO_3.
B_7	22.5g Clay + 1.50g PacR +1g Na_2CO_3.

Table 6: Beneficiation of Samples

SAMPLES	600 rpm FANN reading	300 rpm FANN reading	Plastic viscosity (Cp)	Yield Point YP(lb/100sqft)	YP/PV Ratio	10Sec Gel(lb/100sqft)	10min Gel (lb/100sqft)
A1	15	9	6	3	0.5	3	5
B_1	14	9	5	4	0.8	0	1
A_2	21	12	9	3	0.333	0	0
B_2	19	10	9	1	0.111	0	0
A_3	25	18	7	11	1.57	0	0
B_3	24	16	8	8	1	0	0
A_4	28	22	6	16	2.67	0	0
B_4	27	21	6	15	2.5	0	0
A_5	38	29	9	20	2.2	0	0
B_5	37	28	9	19	2.1	0	0
A_6	38	29	9	20	2.2	0	0
B_6	37	28	9	19	2.1	0	0

Table 7: Samples with optimum additives

SAMPLE NUMBERS	A6	B6	SPECIFICATION
Moisture %	3.23	3.95	10max
Screen Analysis	2.15	2.30	4max
BENTONITE PROPERTIES. Bentonite 22.5g per 350ml water			
600rpm reading	38	37	30min
300rpm reading	29	28	
Plastic viscosity	9	9	
Yield Point	20	19	
10sec Gel lb/100sqft	0	0	
10min Gel lb/100sqft	0	0	
PH	10	10	
Filtrate Volume	12	14	15max
YP/PV Ratio	2.22	2.1	3max
Ca^{++}	-	-	250max
% Sand content	Trace	Trace	Trace

Table 8: Mud preparation (KCl polymer mud)

	A	B
600 rpm Reading	74	100
300 rpm Reading	47	74
Plastic Viscosity (Cp)	27	26
Yield point lb/100sqft	20	48
YP/PV Ratio	0.74	1.85
10 sec Gel lb/100sqft	7	9
10 min Gel lb/100sqft	12	17
pH	10	10
Filtrate Volume	8.5	9.5
200 rpm Reading	31	61
100 rpm Reading	26	40
6 rpm Reading	11	16
3 rpm Reading	8	14
Pm	1.2	1.2
Apparent Viscosity (Cp)	37	50
Density of mud kg/m^3	997.2648	1000.49
Specific gravity	1.2	1.2

Table 9: Result for filtrate analysis on mud

	A	B
Phenolphthalene test Pf	0.2	0.3
Methyl blue test Mf	1.2	1.3
Filtrate Volume	6ml	5ml
OH^-	0	0
CO_3^{--}	240	366
K^-	45000	45000
HCO_3^-	976ml	754ml
Ca^{2-}	16ppm	10ppm
Cl^-	35900mg/l	35000mg/l

DISCUSSION OF RESULTS

The characteristics of the samples and their responses to additives incorporated are discussed as follows.

Viscometer Dial Reading

The viscometer dial reading at 600rpm for the physical requirement of bentonite clays is 30 Cp minimum (API, 1990). Samples A and B gave results of 9Cp and 10Cp, respectively as, shown in Table 4, which were below the standard specifications.

Sodium bentonite has high dispersion properties in aqueous mixture and developed high viscosity and gel strength. They also developed low fluid loss values.

Afuze and Maiduguri clays consisted of clay minerals with low montmorillonitic content which accounted for low viscosities and gel strength values.

Beneficiation results of the samples (A_1 to A_5) and (B_1 to B_5) did not meet up with the minimum requirement but A_6 as well as B_6 did give results as 38Cp and 37Cp, respectively, as shown in Table 7.. This was achieved by the gradual increase in the quantity of polymer from 0.25g to 1.5g. Another additive which is Na_2CO_3 was added again to obtain the optimum result as A_7 and B_7.

The initial low values can be said to due to clays being composed largely of calcium ions since clays with high calcium content gave low viscosity dial readings when added to water.

The experiment showed that the samples used have similar properties. It was noted that A and B have low viscosities and high water loss properties.

Finally, the proportional increase in viscometer dial reading could be said to be due to the addition of additives which might have increases sodium ion (Na^+) thereby increasing the viscosity. As a consequence, A and B therefore could be said to contain clay minerals of calcium ions.

Yield Point/ Plastic Viscosity (YP/PV)

The yield point/plastic viscosity ratio specification by API is 3 maximum. All samples results (A_1 to A_7) and (B_1 toB_7) in Table 5 and 6 met up to this requirement. Result of (A_1 to A_7) and (B_1 to B_7) ranged from 0.25 to 2.7 and 0.8 to 2.5 in Table 6.

Filterate Volume

The API specification for filtrate volume is 15cm^3 maximum. Samples A and B gave 80 and 88 respectively in table 4. In the beneficiation process the addition of various amounts of Pac R improved the fluid loss correspondingly with the best results obtained in A_6 & B_6, after the addition of 1.5g of Pac R, fluid loss reduced to 12 & 14 for A & B respectively. These suggest that the basic function of Pac R is filtration control.

Residue/ Sand Content

The sand content for samples A and B were found to be negligible which thus satisfies API specification of being Trace.

Moisture Content

The moisture content of samples A & B were found to be 3.23% and 3.95% respectively, and they met with the specified requirement of 10.0wt % maximum.

Screen Analysis

Residue greater than 75 micrometer in samples A and B were found to be 6.9 and 7.5 respectively. These were in excess of API requirements, which specifies 4.0 maximum.

pH

The pH requirement by API is between 9 and 11, which are in the alkaline range. The pH of A and B were found to be 8 each. The addition of 1g of Na_2CO_3 increases the pH of the samples to 10 each in table 7. This result lies within the range of the specification. Caustic soda is used to effectively control the pH of mud.

The analysis of sample A and B show that they are both of low grade and with similar properties. Both have similar and proportional increase or responses to the same quantity of additives added. Both were upgraded with 1.5g of polymer and 1g of Na_2CO_3.

Discussion of Results for Mud Preparation

KCl polymer mud

The chloride ion concentration of the KCl polymer mud prepared with samples A and B were found to be 35900mg/l and 35000mg/l which fall within the range of 30,000 and 100,000 ppm as shown in handbook.

Carbonate and Bicarbonate ions were found to be 240ml and 976ml, and 366ml and 754ml for A and B respectively. Their specific gravities were found to be 1.2 each. Filtrate volume obtained was 8.5 and 9.5 respectively. Their pH is also 10 each, which fall within the range of 9.5 and 10.5 as stated in handbook.

CONCLUSION

From the results obtained, the following conclusions can be drawn.

Afuze and Maiduguri clays, which were tested, were of low grade because they failed the required specification of real bentonitic clays, which are the rheological properties. However, they can be upgraded by the use of biopolymers and sodium carbonate salt.

RECOMMENDATION

Different viscosifiers should be used for the beneficiation of samples from the same source so a definite and precise comparison can be made.

REFERENCES

Bariod Fluid handbook, 1996. Baroid Drilling Fluids, Inc. Revised Edition.

Brantly, J.E., 1953. History of Oil Well Drilling, McGraw Hill Book Company.

Charles Kirkley, 1990- Rotary Drilling "Drilling Mud", Unit 11 lesson, 23 rd Edition, Petroleum extension services, University of Texas.

Dawodu, E. O., (2003). Production of Drilling Mud from Local Clays, (unpublished). B.Eng. Thesis, Chemical Engineering Department, F.U.T.,Minna, Nigeria.

Drilling Specialist Company, Technical Services division, Bulletin No 240.Investment Profile for Nigeria Vol 1. A Publication of R.M.R&D Council 1992, Lagos Nigeria.

John, C. R. (1996). Environmental Control in Petroleum Engineering, Gulf Publishing Company, Houston, London, Paris, Zurich, Tokyo.

Narrisa Okonkwo.A., 1990. Term paper on the Technology and Functions of Drilling Fluid in Oil Wells. Petroleum Training Institute Warri.

Pennington J.W History of Drilling Technology and its Properties Dec1949.

Raw material sourcing for manufacturing in Nigeria R.M.R&D Council Abuja 3rd Edition July 1997.

Grim R. E., 1968. Clay Mineralogy 2nd Edition. McGraw Hill.

Rutley, (1988). Elements of Mineralogy 27th Edition. Revised by Gribble.

Specification for Drilling Fluid Materials.1990. API Specification 13A (Spec 13A), 13th, Edition.