DRILLING FLUIDS: PROPERTIES AND TREATMENT OF SOME NIGERIAN CLAYS

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ABSTRACT

Clay samples from ten towns in seven local government areas of Rivers and Bayelsa States, namely, Oboburu and Omoku (ALGA), Kono (BOLGA), Bakana (DELGA), Ndele (KELGA), Borokiri (PHALGA), Akaranbiri (SALGA), Agidama, Igbainwari and Sabagrei (YELGA), were collected and analysed for their mineraology and rheology in the laboratory. In their native states, these samples were not suitable for the preparation for drilling mud, since their properties fell below the API (American Petroleum Institute) specifications. From the results of the x-ray diffraction analysis and the methylene blue test on the native clay, they were found to contain chiefly kaolinite group clays. However, the results were encouraging when the native clays were treated with mud additives like quicktrol, sodium hydroxide and sodium carboxy methyl cellulose (CMC). Varying the amount of chemical additives, the best results were obtained when 2 grams quicktrol and 0.25 gram of sodium hydroxide were added. All rheological and wall-building properties after the treatment compared well with the standard Wyoming bentonite.

Keywords: *American Petroleum Institute (API), Bentonite; Rheological, Wyoming; Quik-Trol; Mineralogy, Mud Density.*

INTRODUCTION

Since the advent of rotary drilling in the oil industry, drilling fluids have been used as the circulating agent to ensure primarily the removal of cuttings from the wellbore to the surface, hole stabilization and pressure control by the mud density. They were first introduced in the rotary drilling method between 1887 and 1901 (Chillingarian, et al, 1981). As rotary drilling developed, more engineering attention was drawn and its function have been broadened, which demanded its compositional increase. It has become a complex mixture of liquids and chemicals.

Drilling activities started in the early 1950s in Nigeria and it witnessed the use of available local clays until the early 1960s when Nigeria started making use of imported clays especially from the United States of America. An average of 2.4 tonnes of bentonite is used per 1,000ft drilled, which implies that an enormous quantity of bentonite is imported every year from abroad (Rai et al, 1982). In the 1980s some works has been done in preparation of drilling fluids with local clays in some parts of the country which yield good results after treating the rheological properties with drilling fluid additives (Akanaga, 1984; Okere, 1984; Rai et al, 1982, etc).

However, the aim of this study is to analyze the mineralogy and the rheological properties of some ten clay samples, each from different locations from seven local government areas in Rivers and Bayelsa States of Nigeria. Their properties are to be compared with those of the Wyoming betonite to see whether they are suitable for drilling fluid preparation. If not, to subject them to some chemical treatment to upgrade the rheological properties to be comparable to these of the standard Wyoming bentonite. Some of these treatments are summarized herein;

a. Chemical Treatment Of Water-Base Muds

In water base muds, water is in the continuous phase with colloidal and inert particles suspended in the mud. These suspended materials alter the composition of the mud, thus filtration losses, funnel viscosity, gel strength, etc. may then deteriorate. The physical and chemical properties of water-base muds have to be controlled therefore, for optimum performance and facilitate their dispersion in water, raise viscosity and gel strength, reduce corrosive activity, etc.

The viscosity, gel strength, mud weight and fluid loss are important since these are related to the suspension of cuttings and weighting materials when drilling is stopped, removal of cuttings at the borehole to the surface and release of cuttings at the surface. A satisfactory fluid loss value and decomposition of a thin impermeable filter cake are the determining factors for the successful performance of a drilling mud. Fluid is lost from the wellbore to the formation. Excessive loss of filtrate into the formation leads to thicker cake build-up and cause problems such as increase pressure surges, differential pressure sticking and drill strings, excessive formation damage etc.

The hydrostatic pressure of the drilling fluid column has to be greater than the formation pressure if the formation fluids have to remain in their native location during drilling. If the formation pressure is greater than the hydrostatic pressure, then an influx of formation fluid into the wellbore takes place, thus adequate mud weight is needed to prevent influx of formation fluids. Conversely, if the mud is too heavy, there will be lost circulation, swabbing and pressure surges when drill-pipes or casings are pulled out opt lowered.

b. Chemical Thinners (Dispersants)

These are organic or inorganic compounds that reduce the viscosity and gel strength of drilling fluids by preventing the formation of a “brush-heap” structural configuration of clay practices. Organic thinners can be used in deep wells since they have more temperatures resistance. Examples of inorganic thinner are;

(i) Sodium-acid-pyrophosphate,
(ii) Sodium-tetraphosphate,
(iii) Tetra-sodium-pyrophosphate
(iv) Sodium-Hexametaphosphate.

Organic thinners are lignin, Tanin, and Lignosulfonate. Caustic soda (NaOH) and quebracho mixtures are powerful and commonly used thinning solutions.

c. Filtrate Loss Control Agents

These agents lower fluid loss during drilling. Examples are starch, polymers, etc. Starch, which is made from corn (maize), is an organic colloid, which when added to drilling mud system swells and gelatizes rapidly in fresh or salt water. It should be used with such preservatives such as paraformaldehyde to prevent it from fermenting.

d. Polymers

These are classed according to their action within a mud system. The classification is based on the adsorption unto the solids or by viscosifying the mud phase. Some polymers used in the oil industry include sodium çarboxy-methyl cellulose (CMC), polyacrylonitrite (cypan) and resinex.

METHODOLOGY

The native clay samples are labeled alphabetically from A to J, with K being the Wyoming bentonite sample. Samples A, B and C are from Igbainwari, Sagbagrei and Agadima, respectively, all in the Yenegoa Local Government Area (YELGA). Samples D and I are from Oboburu and Omoku, respectively, both in the Ahoada Local Government Area (ALGA). Samples E Ndele in the Ikwerre/ Etche Local Government Area (KELGA); Samples F from Akarambiri in the Sagbama Local Government Area (SALGA); Sample G from Bakana in the Degema Local Government Area (DELGA); Sample H from Borokiri in the Port Harcourt Local Government Area (PHALGA); and Sample J from Kono in the Bori Local Government Area (BOLGA).

Ten samples of clay were collected from different locations in the Rivers and Bayelsa State of Nigeria and their mineralogy, rheological, fluid loss and wall building properties were investigated, after the samples were dried and ground in the laboratory. The samples were labeled A, B, C, D, E, F, G, H, I and J. Their properties were then compared with those of the standard Wyoming bentonite, labeled k. The preparation of drilling fluids (mud) with these samples in the laboratory to determine their suitability for drilling fluid began with mixing measured quantities of the samples in 20, 40, 60 and 80gm. Each quantity was then mixed with 350cc of distilled water and stirred thoroughly with the Hamilton Beach Mixer for some time to obtain a uniform mixture and to hydrate the clay particles.

First and foremost, the mineralogy of the samples were determined using the X-Ray diffraction analysis method for samples A, B, C, D, E, F and K. Due to circumstances beyond our control, we were not able to analyze samples G, H, I and J using the X-Ray diffraction method, instead we did the methylene blue test on them, to estimate their Cation Exchange Capacity (CEC) values. For the common clay minerals, their CEC values in milli-equivalent/l00gm of clay are shown and those of samples G, H, I, J and K are also shown. A variable Fann VG meter was then used to measure the dial readings of 600RPM (∅600) and 300RPM (∅300), from which the plastic viscosity (PV) in centipoises (cp), yield point (YP) in lb/lOOft^2 and apparent viscosity (AV) in cp were calculated. The densities of the prepared muds were measured with the mud-weight balance after the initial and the 10 minutes gel strengths were recorded.

DISCUSSION OF RESULTS

The filtration, water loss, or wall building test was conducted with a filter press. It consists of determining the rate at which filtrate (continuous liquid phase of the mud) is forced from the sample under a specified pressure (100 psig). Both the filtrate volume (cc's) and the mud cake thickness (32nd of an inch) were recorded. The standard time of the test is 30 minutes; hence the water loss is reported as cc's per 30 minutes. The results of the native clay properties as well as those of the imported bentonite are shown.

To up-grade the properties of the native clay samples, mud additives like CMC, Quick-Trol, NaOH and bentonite itself, were added in varying quantities as shown in the investigations done by Bindei (1987) and Pepple (1987). The case where the native clay samples were treated with 2gm of Quick-Trol and 0.25gm NaOH, gave the best results. Cost analysis was also carried out on the native clay samples as compared to the imported Wyoming bentonite, using values from Isabog Nigeria Limited price list. For the native clays, we assumed a price Lag of N15.00 per 25 kilograms.

The clay samples studied were not suitable for the preparation of drilling muds in their native states. This was because their rheological and filtration properties did not measure up to the API standard. For example, the API specification for sodium-montmorillonite is 11cc for fluid loss, 8.2 for pH and 125 bbl/2000 lb for l5cp mud (Chillingarian et al, 1981).From collection it was shown that clay minerals presently in the native clay samples were mostly kaolinite group, whereas that of the Wyoming bentonite was mainly montmorillonite group. The total clay minerals in samples A, B, C, D E and F- ranged from 67-85%, while that of sample K was 90%, using the X-ray diffractograms analysis. From the methylene blue test, montmorillonites have CEC value of 70 - 130 milli-Equiv./l00gm of clay. For samples G, H, I, J and K, it was observed that the results of the methylene blue test (MBT) increased as the concentration of the clay increased. From the results it was clearly shown that the native clays (Samples G, H, I and J), with CEC values of between 3 and 15 milli-Equiv. per 100gm. of clay, were mostly kaolinite group. For the case of the sample K (with CEC value of 76 at a concentration of 80gm/350cc of water), it was again shown to belong to the montmorillonite group.

The rheological properties of the native clays were very low as compared to that of the sample K. The PV of all the samples in their native states was very low compared to that of sample K as shown in fig. 1. That of sample K, were 2, 41 and 25cp. for concentrations of 20, 40 and 60gm/350cc of water respectively. When treated with 2gm of Quick-trol and 0.25gm of NaOH, all the samples showed remarkable improvement with sample 3 appearing to be the best of the native clays, in terms of viscosity behaviour, as shown in Fig. 2.

The initial (10 seconds) and 10 minutes gel-strengths plots of the native clays are shown in Fig. 3. They increased with increase in concentration, but with very low values as compared to those of sample K. For sample K, the 10 seconds gel strengths were 4.5 and 110 for concentrations of 20 and 40gm per 350cc of water respectively and the 10 minutes gel strengths were 15 and 240 for concentrations of 20 and 40gm per 350cc of water respectively. On treatment with the 2gm of Quick-Trol and 0.25gm of NaOH their gel strength properties became remarkably favourable, but still below that of Wyoming bentonite (sample K), for concentrations above 30gm/350cc of water for 10 seconds gel strength (see Fig. 4) and for concentrations above 25gm/350cc of water for 10 minutes gel strength (see Fig 5).

The mud densities at various concentrations for each of the samples in their native states and when treated were almost the same and were very well comparable to that of sample K and also show that the pH of the native clay samples were about 6 respectively, while those of the treated clay samples were 10 respectively as compared to that of sample K, which was about 8. The pH helps in the chemical control of the muds as well as indicating the presence of contaminants such as cement and gypsum.

The filtrate loss for the samples in their native states were too high compared to those of the bentonite sample, as shown in Fig. 6. The filter loss of Sample F was the lowest among the native clay samples. Its fluid loss values were 67, 54,48 and 42cc. for concentrations of 20, 40, 60 and 80gm/350cc of water respectively, whereas those for bentonite were 19.5, 13, 11.5 and 7cc for 20, 40, 60 and 80gm/350cc. of water respectively. As shown in Fig. 7, significant improvements were recorded in the filtrate loss values after the treatment with quick-trol and NaOH. In this case, the results obtained for all the samples except samples I and J was fairly comparable to those of the bentonite (sample K).

The filter cake thickness of the samples for the given concentrations was comparable to those of the bentonite. However, they were slightly decreased after the treatment, but still remain in a fairly good range. Generally, the sand contents were low. However, the absence of bigger sand sizes was advantageous because sand in mud causes abration of pump parts and pipe connections which result in costly repairs or replacements. The bigger sand sizes were settled out of the continuous phase before the mud was decanted for the density measurement.

The prices of chemicals used in the petroleum industry have risen tremendously in recent times. Fig. 8 is a plot of the cost versus concentration of the bentonite, native clays and the chemically treated native clays. The linear relationship between the cost and the concentration for the three different cases is clearly shown. At lower concentrations, bentonite compares well with the chemically treated native clays in terms of cost. With further increase in concentration, the treated native clays costs are lower than that of the imported bentonite. On a much larger scale, as in drilling operations, concentrations in tonnes of drilling muds are involved. The use of bentonite thus entails higher costs, whereas the use of chemically treated native clays would reduce costs, as the concentration increases.

CONCLUSION

From the experimental results obtained on the native clay samples, the following conclusions can be drawn;

1. The ten clay samples from seven different local government areas of the Rivers and Bayelsa States were not suitable in their native states, for the production of good drilling muds.
2. The clay samples consist mainly of kaolinite clay group. These clay deposits are therefore of interest from the view point of production of mud, after chemical treatment.
3. The rheological and wall-building properties showed a high degree of improvement after chemically treated with 2 grams of Quick-Trol and 0.25 gram of Sodium Hydroxide.
4. The fluid loss was significantly reduced when treated and the results obtained compared well with that of standard Wyoming bentonite.
5. The use of chemically treated Rivers and Bayelsa States native clays for the production of drilling muds entailed much lower cost than the use of imported standard Wyoming bentonite.

RECOMMENDATIONS

Based on the findings of this study, the following recommendations are submitted:

1. Clay should be inspected accordingly by specialist in order to determine suitability for production of good drilling muds.
2. Chemical treatment of clays with appropriate quantity of Quick-Trol and Sodium Hydroxide should be considered as it has been proved to show high degree of improvement on the rhealogical and wall-building properties.
3. Since chemically treated native clays of the study areas entail lower cost, it is economical for chemical treatment of clays be adopted.
4. The Government, the major oil companies and stake holders should encourage large scale production and utilization of the local clay for production of drilling mud if we must meet our target of becoming one of the top economic countries of the world.

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APPENDIX

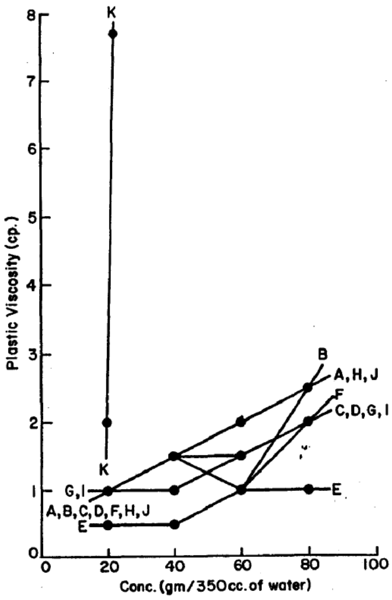

Fig. 1 Plastic Viscosity vs. Concentration of Samples in their Native States

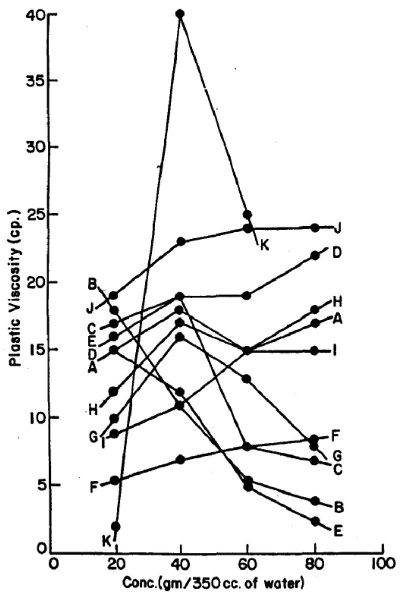

Fig. 2 Plastic Viscosity vs. Concentration of Samples Treated with 2 gm. Quick Trol and 0.25 gm NaOH

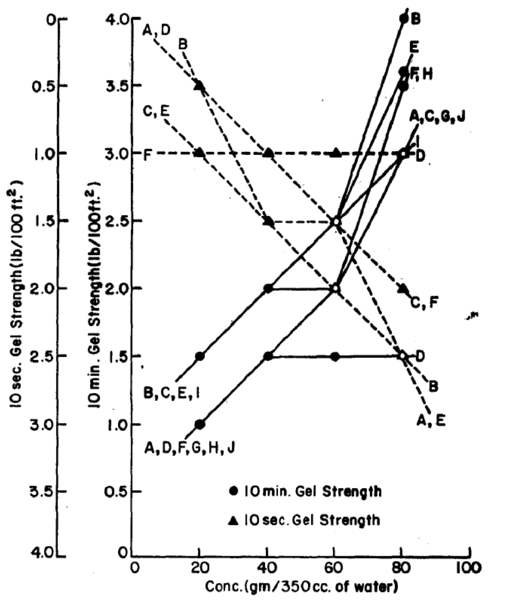

Fig. 3 10 sec. and 10 min. Gel Strength vs. Concentration of Samples in Their Native States

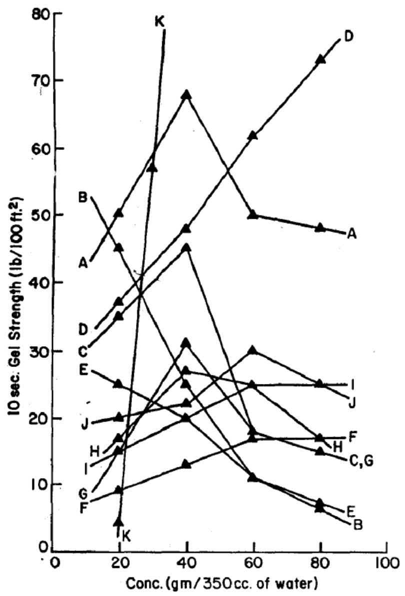

Fig. 4 10 sec. Gel Strength vs. Concentration of Samples Treated with 2 gm. Quick Trol and 0.25 gm. NaOH

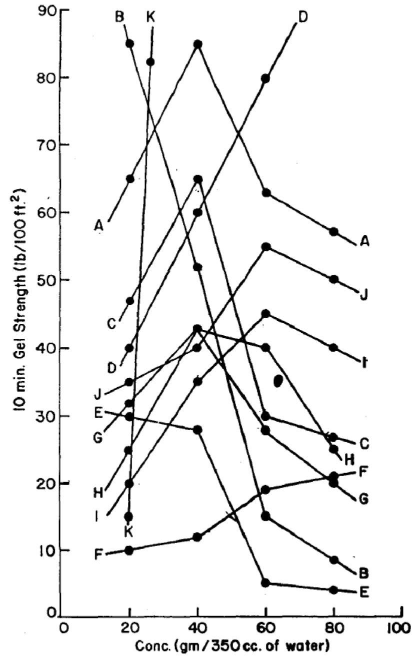

Fig. 5 10 min. Gel Strength vs. Concentration of Samples Treated with 2gm Quick Trol and 0.25 gm NaOH

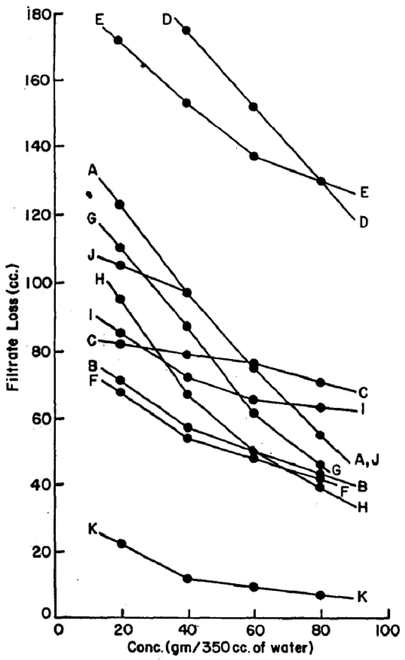

Fig. 6 Filtrate Loss vs. Concentration of Samples in their Native States

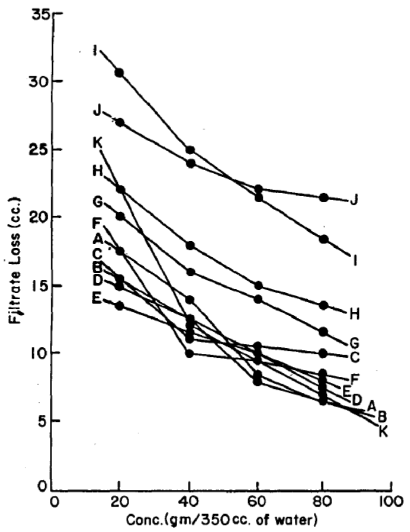

Fig. 7 Filtrate Loss vs. Concentration of Samples Treated with 2 gm Quick Trol and 0.25 gm NaOH

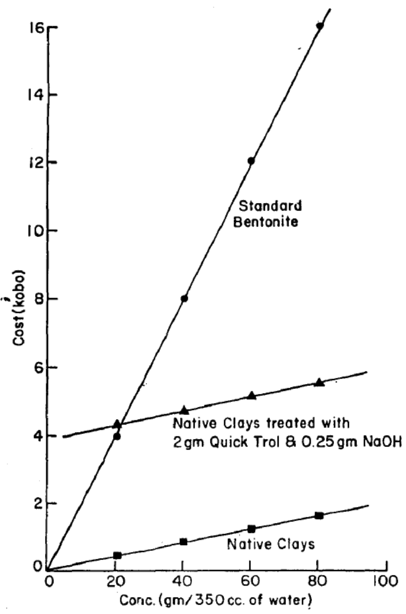

Fig. 8 Cost vs. Concentration of Samples of Standard Bentonite, Native Clays and Chemically Treated Native Clays