Effect of Local Clays Substitution on Rheological Properties of Formulated Water Base Mud

Temple Emeline Adaoma[1], Wami Emenike Nyechel[2], Wami Emenike Nyechel[2], Nmegbu Godwin,C.J.[3]
1 Department of Petroleum Engineering, Rivers State University, Port Harcourt.
2 Department of Chemical/ Petrochemical Engineering, Rivers State Universiy, Port Harcourt.
3. Department of Petroleum Engineering, Rivers State University, Port Harcourt.
1.emelinetemple@yahoo.com

Abstract— *Filtration loss and rheological properties of drilling fluid significantlyrelies on the quality of bentonite clay and chemical additives used in formulating the mud. In search for suitable substitute for foreign bentonite clay to be used in formulating drilling fluid in petroleum industry in Nigeria, physicochemical and rheological properties such as swelling index,cation exchange capacity, yield point, gel-strength, Yield point-plastic viscosity ratio of local bentonite clays from Andoni,Bolo and Etche communities in Rivers State, Niger Delta of Nigeria were determined and compared with foreign bentonite clay. The laboratory investigations on swelling volume and cation exchange capacity test revealed that the local clays in their raw state, do not possess appreciable swelling due to high concentration of calcium ion (Ca^{2+}) than sodium exchange cation (Na^{+}).But when beneficiated with adequate concentration of sodium carbonate (Na_2CO_3) per laboratory barrel (17.5g clay/350ml water) there was remarkable improvement. Filtratio loss reduced from 17.10ml, 16.8 and 16.20ml to 10.70ml, 9.0 and 10.0ml while rheological properties improved significantly, with Yield point from 6-62Ib/100ft^2, 7-58Ib/100ft^2 and 16-68 Ib/100ft^2,10mins gel strength also increased from 2-32 Ib/100ft^2, 3-40 Ib/100ft^{2}and 6-45 Ib/100ft^2 for Andoni, Bolo and Etche muds respectively. These properties were comparable with Foreign bentonite clay & API standard which indicated that the local clays have potentials of being substituted for foreign clay when adequately beneficiated.*

Keywords: Additives, Beneficiation, Clay, Drilling mud, Fluid loss, Rheological properties

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1 INTRODUCTION

Drilling fluid is one of the important materials used in drilling operations. It is a composition of solids, liquids and gases distributed throughout a liquid or gaseous phase which is circulated through the wellbore during rotary drilling process . A properly formulated drilling mud will enable the operator to achieve the desired target at minimum overall cost, improve penetration rates, reduce hole problems and minimize formation damages. Major problems encountered during drilling operation may be attributed directly or indirectly to the quality of drilling fluid used. Clays are easily molded into a form that they retain when dry and they become hard and lose their plasticity when subjected to heat.Swelling property of clay is a vital characteristic of drilling fluid as it enables the fluid to form thioxotropic gel which suspends the drill cutting during work over and pipe tripping.

Industries involved in the design and production of drilling fluids in Nigeria have over the years imported bulk drilling fluid materials, modify the properties of the drilling fluid with the aid of the right types of additives which are likewise imported to suit the formulation requirement of the formation to be drilled and in some cases already designed and produced drilling mud (Odumgbo, 2005). The importation of foreign bentonite for drilling mud formulation has continued to avert some huge sum of foreign exchange that would have impacted on the financial prosperity of Nigeria despite an indication of enough bentonite clay reserve in the country (Apugo-Nwosu *et al*, 2011, Dewu *et al*, 2011). Although greater part of clays sourced locally are calcium bentonite and of lower swelling index when compared with sodium bentonite with high swelling index and low fluid loss (Folade *et al.*,2008, Nweke *et al.*. 2015).Research findings have demonstrated that calcium bentonite can easily be upgraded to sodium bentonite (Biliamino and Ibrahim, 2010).Exploration of local clay material and additives that could be suitable for drilling fluid formulation is encouraged, although much has not been done in the design of such drilling mud systems with our own local clays.Abuh et *al.* (2014) in their study revealed that Adiabo clay from Calabar cannot be used as drilling mud in its native state but suitable for other industrial applications. (Mihalakis *et al.*, 2004) reported that the rheological properties of the black cotton clays improved with addition of Na_2CO_3.Okologume and Akinwumi (2016) concluded that Abbi clay from Delta state is suitable for mud formulation when treated with chemical additives,. Okogbue and Ene (2008) revealed that some Southern Nigerian natural clays possess properties that are somewhat similar to those naturally active bentonite clays..The aim of this research work is to modify local (Nigerian) clays by beneficiating with additives and to investigate their effect on rheological properties .

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2. MATERIALS AND METHODS

2.1 Equipments used for this study include: Fan VG meter to determine mud rheological properties; API filter press,for filtration loss determination; Bariod mud balance to determine mud density; Digital weighing balance to measure weight of samples to be analyzed; Digital pH meter for measuring mud pH; Sand content kit, to determine the quantity of sand in the prepared mud; Hamilton beach mixer; Graduated cylinder, used for measuring liquid volume; Mortar & Pestle for pulverization of clay sample ,Oven Dryer of range 50^OC to 400^OC to dry samples; 75-200micron sieve and spatula. Materials & chemicals used are: Local clay samples, foreign clay (Bentonite), distilled water/deionized (H_2O), Caustic soda (NaOH), Soda ash (Na_2CO_3), Polyanionic Cellulose Regular (PAC-R), Potassium chloride (KCl), Barite and Xanthan gum.

2.2 Sample Collection

Clay samples were sourced from different geographical locations within Rivers state, namely Andoni (Inyongonrong), Bolo and Etche (Egwi) Local government Area at a depth of about 4.57m where sodium, calcium and magnesium base elements tend to accumulate (Okologume and Akinwumi, 2016). About 1kg of wet raw samples were collected at each location and carefully bagged in a foil paper, labeled sample A (Andoni), sample B(Bolo) - both of which are grayish dark in colour, sample C(Etche), brownish and sample D(Foreign bentonite clay),whitish in colour.The samples were taken to the laboratory for analysis. The foreign bentonite clay sample (The control) was obtained from a reputable international oil servicing company in Port-Harcourt, Nigeria.

2.3 Sample Preparation

The clay samples were soaked in water for 72hours and stirred every 24 hours to release organic materials. After 72 hours, the clays were sieved using a 200 mesh sieve and allowed to settle down. The clay samples were then transferred to a thimble for dewatering ,dried to a constant weight in an oven at a temperature of 105^oC and subjected to pulverization by pounding in a mortal. The pulverized clay samples were sieved with a 75-micron sieve to obtain fine powdered clay particles. 17.5g of fine powder of each clay sample was blended with 350ml of distilled water in a Hamilton beach mixer for 30minutes and then

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allowed to settle for 24 hours for proper hydration. The prepared clay samples were characterized and the results were compared with the standard foreign bentonite (Control) of equal concentration.

2.4 Swelling Volume Test

ASTM-D5890 method was used to determine the swelling volume.2.0g weight of each dried and sieved clay samples were accurately measured with a balance of low weight. With a measuring cylinder filled with de-ionized water to 100ml, 0.25g of each clay samples were transferred unto the surface of the water using spatula. A minimum of 10 minutes interval must pass between additions to allow for full settlement of the clay to the bottom of the cylinder. These steps were followed progressively until the entire 2g powdered clay had disappeared into the water. The samples are then covered and protected from disturbances and allowed to age for a period of 16-24hours at which time the level of settled and swollen clay is recorded to the nearest 0.5ml.

2.5 Cation Exchange Capacity Test

1.5g of each of the clay sample was placed in a round bottom flask . 20ml distilled water were added to each sample and to agitated for 30minutes. They were left 24hrs to hydrate. The clay samples were transferred to 100ml flask and 1ml of 5M sulphuric acid was added to each of the samples to increase the acidity. 0.01M methylene blue chloride was prepared using distilled water. 2ml of the 0.01M methylene blue chloride was added intermittently to each of the clay samples until end point was reached. After 2ml addition, a drop of suspension was placed on a filter paper using a glass stirring rod ("spotting"). End-point was considered to have reached when spotting produced a dark blue spot of clay absorbed dye surrounded by a pale blue halo of excess dye like sunshine.

2.6 Clay Beneficiation

The local clay samples obtained were treated or beneficiated to improve the properties suitable for use as drilling mud. This was achieved by thoroughly blending 17.50g of each clay sample with 0.2g, 0.5g and 1g of sodium carbonate with 350ml of distilled water in a Hamilton beach mixer for 30mins.The mixtures were allowed to settle for 24hours for proper hydration and aging. Sodium carbonate was used to replace calcium ion which is dominant exchangeable cation in the clays and improve swelling capacity of the clay samples.

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3 MATERIALS AND METHOD

3.1 The results of swelling volume test revealed that all the local clay samples analyzed do not possess any appreciable swelling in their native state as compared with foreign bentonite.. The weak swelling property isas a result to the presence of low expansive montmorillonite which can be attributed to high concentration of Ca^{++} and low concentration of Na^{+}. Andoni clay recorded the lowest swelling volume of 12% while Bolo and Etche recorded 20% each.

3.2 Cation Exchange Capacity

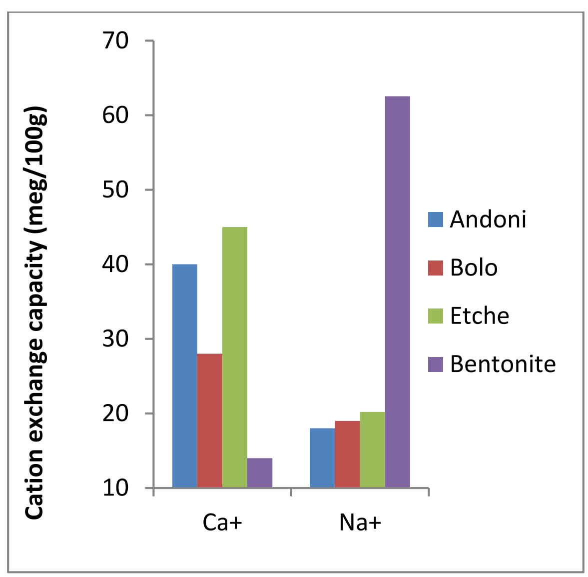

Fig 1: CEC of local clays in their native state

In Fig.1 above Ca^{2+} is the dominant in all the local clay samples in their native. This indicates that the local clays are Kaolinitic while Bentonite (foreign) clay is montmorillonite (Taylor,1985).

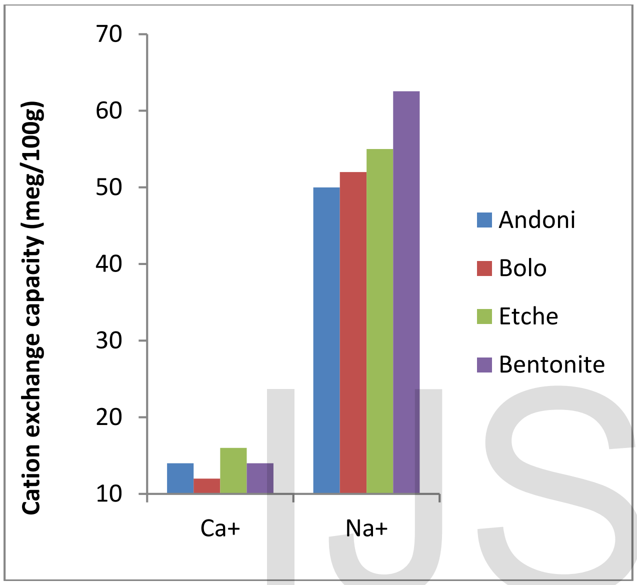

Fig 2: CEC after beneficiated with 1.0g Na_2CO_3

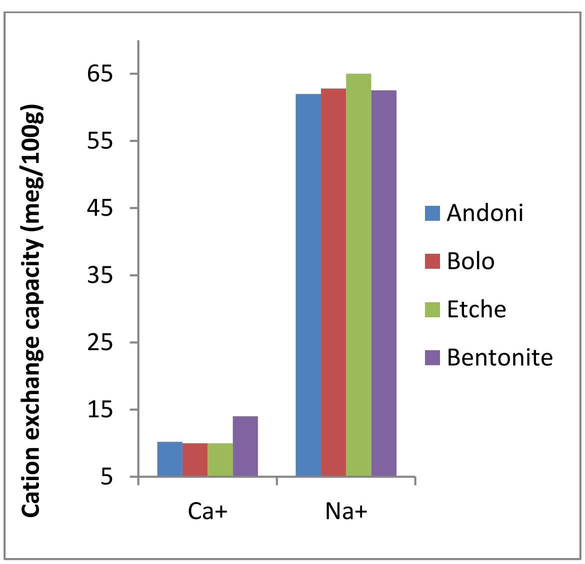

Fig 3: CEC after beneficiated with 2.0g Na_2CO_3

There was a remarkable increase in sodium content when the clays were beneficiated with an increasing concentration of Na_2CO_3.from 18.2 -48Meq/100g for Andoni clay,19-55 for Bolo clay and 20.2 -62Meq/100g for Etche clay.Ion exchange beneficiation significantly improved the sodium content.This implies that the local clays could attain the required API standard when beneficiated with an increased concentration of Na_2CO_3,concentrationabove 1.0g (Mihalakis*et al.*,2004).

3.3 Filtrate Loss: The filtrate loss for the clays in their native states were high compared to bentonite sample and above API minimum value of 15ml.The values were 17.10,16.80 and16.20ml for Andoni, Bolo and Etche clays respectively for clay mixture of 17g/350ml of water. .Significant improvement was recorded in the filtrate loss values after treatment with Na_2CO_3 increasing concentration.

3.4 Rheological Properties

The rheological properties tested for water base mud prepared with API standard composition as includes: yield point, gel strength, yield point-plastic viscosity ratio. Concentration of PAC-R was varied and the other additives were kept constant.

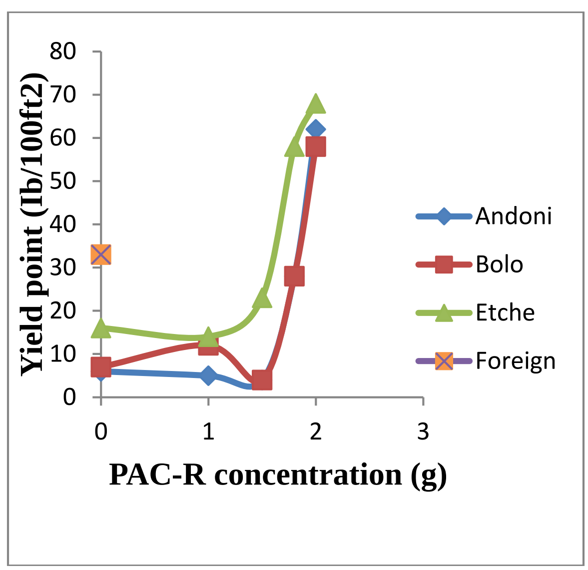

Fig 4: Comparison of Yield point of different

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beneficiated mud samples with bentonite

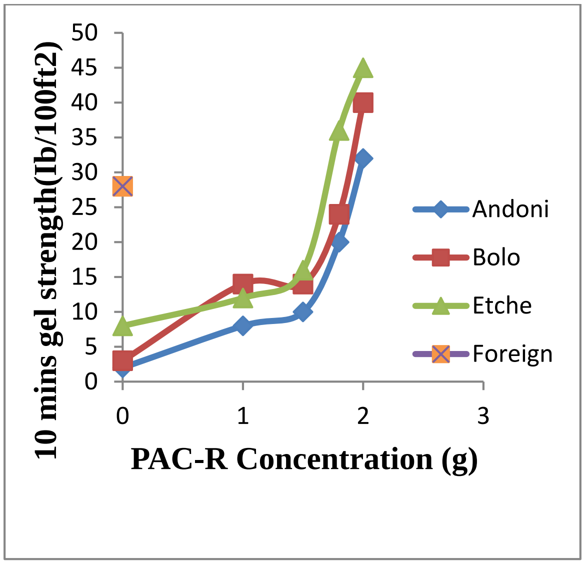

Fig 5: Comparison of gel-strength of different beneficiated mud samples with bentonite.

In **Fig 4 & 5.**There was a decrease in yield point and gel strength value for all the local clays when beneficiated with 1.0g & 1.5g of PAC-R, but further increase in PAC-R content of 1.8g and 2.0g, the yield point and gel strength increased drastically as compared with foreign bentonite .

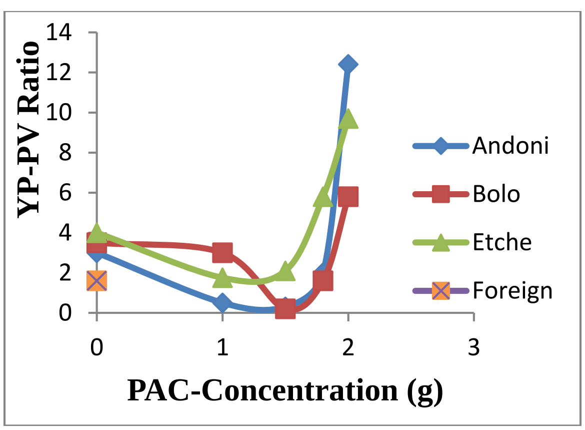

Fig 6: Comparison of Yp/Pv of different beneficiated mud samples with bentonite

The yield point/plastic viscosity results showed that all the beneficiated local clays analyzed at moderate beneficiation up to 2.0g of PAC-R per laboratory barrel were within API standard of maximum 3.This implies that the local clays could be good candidates for drilling mud

4.CONCLUSIONS

This study has evaluated the mud properties of clays from Andoni, Bolo and Etche Local Government Areas of Rivers state, Nigeria and the extent to which beneficiation with sodium carbonate and PAC-R improved these properties for possible use as total substitute for bentonite in drilling mud formulation. Swelling volume and exchangeable cation test carried out on the studied clays in their native state showed weak swelling properties with Ca^{2+} as the dominant exchangeable cation. The native clays were acidic in nature and mud prepared with them possessed relatively low mud and rheological properties. The acidic nature of these clays clays could be attributed to the riverine nature of their location.Beneficiation with sodium carbonate and polyanionic cellulose regular (PAC-R) of average concentration 1.8g - 2.0g and above 1.0g Na_2CO_3 respectively per laboratory barrel(17.5g clay/350ml of water),remarkably improved the local clay mud properties with better results when compared with non-beneficiated bentonite and American Petroleum Institute (API) standards .

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