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Full Length Article

Mineralogy and rheology of raw and activated Turonian to Coniacian clays from Benue Trough, northeastern Nigeria

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ABSTRACT

Since the discovery of oil and gas in Oloibiri, an onshore oilfield located in Oloibiri in Ogbia Local Government Area of Bayelsa State, Nigeria on Sunday 15th January 1956 by Shell Darcy, hundreds of oil wells have been drilled and not a single of these oil wells was drilled without the use of bentonite. This work is aimed at evaluating the rheological properties of raw and beneficiated Nigerian clays to ascertain their worth for use as drilling mud in oil and gas well drilling. This will save foreign earnings used in the importation of bentonite by the oil and gas development companies, create employment opportunity and open a new frontier for solid mineral development. Five clay samples from Pindiga Formation in Benue Trough, northeastern Nigeria were collected and subjected to elemental, rheological and other physical properties tests and analysis, while another portion of same samples were beneficiated using sodium carbonate, gum Arabic and poly-anionic cellulose for rheological enhancement then subjected to same cycle of tests and analysis above. Results obtained indicates that wet beneficiation as adopted in this study has proved to be more effective in Ca and Na ionic exchange. The rheological and other physical properties of the clays attained the standard that is required for use in oil and gas well drilling after addition of 12% sodium carbonate and 1.5 g poly-anionic cellulose. It was also discovered that when the formulation was allow to age (stay for 24 h), it attained optimum rheological requirement with 12% sodium carbonate and just 0.8 g poly-anionic cellulose. The clays studies do not require addition of weighing additive such as barite because of their high iron content which made their density attain the require standard even without additives.

1. Introduction

Bentonite is a rock formed of highly colloidal and plastic clays composed mainly of montmorillonite, a clay mineral of the smectite group, and is produced by in-situ devitrification of volcanic ash. In addition to montmorillonite, bentonite may contain feldspar, cristobalite and crystalline quartz. The special properties of bentonite are an ability to form thixotropic gels with water, an ability to absorb large quantities of water, and a high cation exchange capacity. The properties of bentonite are derived from the crystal structure of the smectite group, which is an octahedral alumina sheet between two tetrahedral silica sheets. Variations in interstitial water and exchangeable cations in the interlayer space affect the properties of bentonite and thus the commercial uses of the different types of bentonite. By extension, the term bentonite is applied commercially to any clay with similar properties.

Depending on the dominant exchangeable cations present, the clay may be referred to as calcium bentonite or sodium bentonite, the two varieties exhibit markedly different properties and thus uses. The terms non-swelling bentonite and swelling bentonite are synonymous with calcium bentonite and sodium bentonite, respectively. When mixed with water, swelling bentonites exhibit a greater degree of dispersion and better plastic and rheological properties than non-swelling bentonites. Natural sodium bentonites, such as those in Wyoming, USA (Wyoming), are comparatively rare although the cation exchange properties of smectite enable the more widespread calcium form to be easily converted to high-swelling sodium bentonite by a simple sodium-exchange process.

Drilling fluid, also referred to in the industry as "drilling mud", is a term that includes most fluids used in the drilling business to facilitate the drilling of oil and natural gas wells. The term includes fluids based upon water, hydrocarbons or gases, together with various additives designed to adjust the properties of the drilling fluid systems. The designed fluid encompasses the functions of cleaning the hole, stabilizing the strata drilled, controlling subsurface

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pressures, sealing fluid losses, enhancing drilling rates and protecting potential production zones while conserving the environment in the surrounding surface and subsurface.

Nigerian Bentonitic clays are mostly Ca-based and contain some impurities such as Si (Quarts), Fe and Ti that could impair their rheological properties and make them not quite suitable for drilling operations [1]. The compendium above also reported that presence of quarts in drilling fluid causes abrasion and wearing of the drilling equipment and as well reduces viscosity of the fluid. However, there is need for the removal of such impurities and use of additives in order to enhance the physico-chemical and rheological properties of the drilling fluid from beneficiated Nigerian Bentonitic clays. Other clays from southern Nigeria were studied by [2], their results suggests that the clay could not meet the required standard because their marginal performance. Similarly, results of study by [3]on some clays from Pindiga Formation suggested that they could give a good promise for drilling purposes at optimum clay and additives concentration.

This study therefore is set out to study in detail that rheological status of raw clays from Benue Trough, subject the clays to beneficiation using gum Arabic, sodium carbonate and poly-anionic cellulose and observe their rheological behavior with regards to the beneficiation and evaluate whether the rheological enhancement is such that the clays can be used for oil and gas well drilling. The additive adopted in this study are quite different from those utilized by earlier worker [2,3].

1.1. Regional geology and location of the study area

The study areas (Fig. 1) covered part of Gombe, Bauchi and Yobe States in north-eastern Nigeria which form part of the sedimentary succession of Gongola basin. The Gongola basin lies within the upper Benue Trough.

The Benue Trough is a linear NE-SW trending trough with a length of approximately 800 km and opens into the Gulf of Guinea where the Cenozoic Niger delta has built out open oceanic crust. It forms the E-W trending Yola arm and a N-S trending Gongola basin along which the study areas are located. The Benue Trough as an integral part of the West and Central African Rift System (WCARS), is the most important Cretaceous sedimentary basin within West Africa [6–8].

The lithostratigraphic sequence of the Gongola basin begins from the bottom with the Bima formation lying unconformably on the Precambrian crystalline basement. Summary of stratigraphic of the Gongola basin is presented in Fig. 2 and other details can be found in [10].

Samples collected for this study are from the Pindiga formation. This formation was first studied by [11] and later named "Pindiga formation" by [12]. The Pindiga formation makes up the greater part of the upper cretaceous deposits of the Benue Trough and it marks the beginning of marine condition proper during the Cenomanian to early Turonian. Its types section from Pindiga stream in the south western part of Gombe shows that it is a thick shaly sequence with intercalations of limestone and some fossils.

The Pindiga formation consists of five members with variable characteristics. The Kanawa member consists mainly of shales and limestones where as Deba-fulani, Dumbulwa and Gulani members are mostly sands deposited during the middle Turonian regression. Fika member is the equivalent of the "Fika shales" of [12] and the upper shaly part of Pindiga Formation. The boundary between the Pindiga formation and the Gombe formation is marked by the bioturbted oolitic ironstone beds.

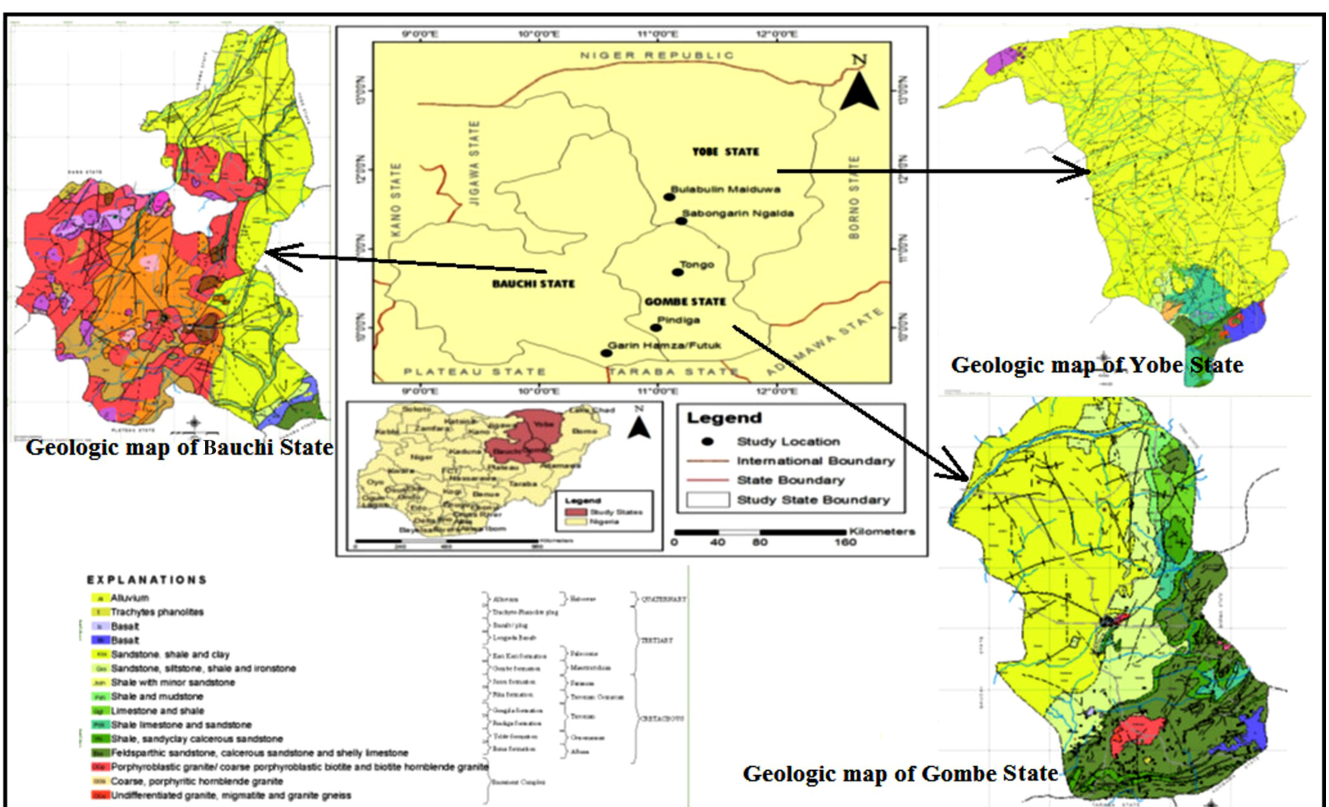

Fig. 1. Geologic and location map of the sampling areas (modified from [4,5]).

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