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Research paper

Morphology, rheology and thermal stability of drilling fluid formulated from locally beneficiated clays of Pindiga Formation, Northeastern Nigeria

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ABSTRACT

Locally beneficiated clays from Pindiga Formation in Northeastern Nigeria have been found to attain standard rheological properties required for Oil and Gas Well drilling after addition of some percentages of poly anionic cellulose. But these properties were measured under ambient temperature (32 °C). There is the need therefore to ascertain the performance of these beneficiated clays at field/down-hole conditions (high temperature and pressure). In this study, three of these clays labeled GHZ, PNG and SGN were chosen because of their high rheological performance among others as already reported in our earlier work, formulated and subjected to different temperature (ambient (32 °C), 40 °C, 50 °C, 60 °C, 70 °C and 80 °C) together with API grade bentonite. At each temperature, their rheological properties were computed to ascertain their performance under these conditions. Physical and other properties (Loss On Ignition, Specific Gravity, Particle Size Distribution, Textural Classification and Formulated CEC) of the sample were also determined and compared with API grade sample. The results obtained indicated that formulation using samples beneficiated with 12% Na_2CO_3 had viscosity values (cP) that ranges from of 2.0–7.9 at temperature ranging from 30 °C to 80 °C with sample PNG recording the highest values of 7.9 cP at 50 °C. For the API grade sample, these values (cP) range from 4.5–16 with highest value recorded at 70 °C. Viscosity results for formulation using same beneficiated sample but with addition of 0.8 and 1.5 g poly anionic cellulose indicated that formulation with 0.8 g poly anionic cellulose had the most impressive improvement among other formulations. The results recorded ranged from 1.0–44 cP with sample PNG recording the highest viscosity of 44 cP at 70 °C. When the Apparent Viscosity (AV), Plastic Viscosity (PV) and Yield Points (YP) of the samples were computed, the results also indicates that sample PNG had the highest values for these parameters compared with the API grade. Other parameters (Loss On Ignition, Specific Gravity, Particle Size Distribution, Textural Classification and Formulated Cation Exchange Capacity) determined had values/behaviors comparable with standard specifications. Thermal stability results indicated that as it is with viscosities of the different formulations at ambient temperature, sample PNG could possibly give a better result (behavior at the measurement conditions) compared with the others even at down-hole conditions and can favorably compete with even the API grade. But at temperatures greater than seventy degrees (70 °C), the performance of both the API grade and the locally beneficiated and formulated drilling fluids began todeteriorate (fail) sharply.

1. Introduction

An increasing world demand for commercial energy will require efficient technologies to recover more oil and gas from reservoirs. Drilling process constitute about eighty percent (80%) of the total well cost (Subhash et al., 2010). Drilling has evolved from vertical, inclined, horizontal to sub-sea and deep-sea drilling. These specialized drilling processes require specialized drilling fluids to fulfill the objectives. Since reservoir type and the drilling process adopted to exploit the reservoir fluid is unique, the drilling fluid has to be customized to suit the drilling process and reservoir conditions (Subhash et al., 2010).

The functions of a drilling fluid includes cleaning the hole,

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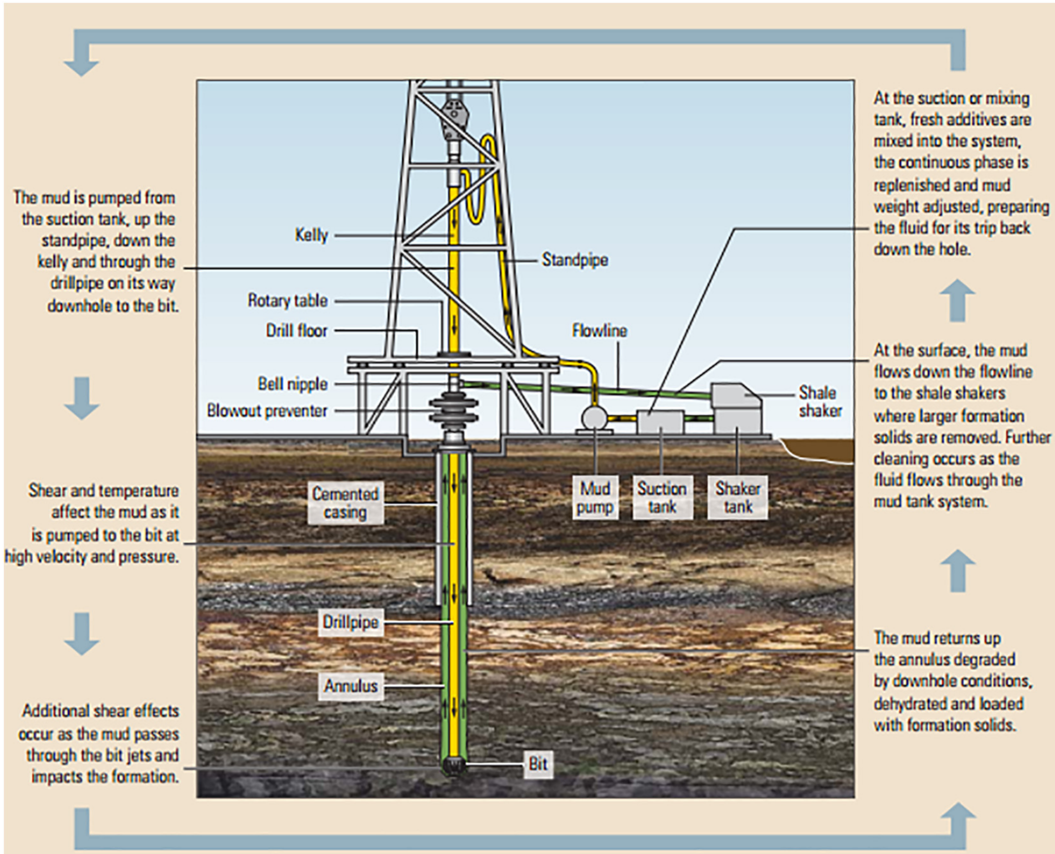

Fig. 1. Drilling fluid life circle.
(Williamson, 2013).

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

The behavior of drilling fluid is affected by increase in pressure and temperature at down-hole conditions. During drilling activities, the drilling fluid is pumped from the suction tank, up the standpipe, down the Kelly and through the drill pipe on its way down-hole to the bit. Shear and temperature affect the fluid as it is pumped to the bit at high velocity and pressure. Additional shear effects occur as the mud passes through the bit jets and impacts the formation. After this process, the fluid returns up the annulus degraded by down–the-hole conditions, dehydrated and loaded with formation solids as demonstrated in Fig. 1.

Works have been conducted on the suitability of clays from different parts of Nigeria for use in the formulation of drilling fluid (Folade et al., 2008; Shuwa, 2011; Arabi et al., 2011, 2017). These clays were confirmed to be Ca-based and could only attain the standard required for oil and gas well drilling after being beneficiated. Arabi et al., 2017 conducted beneficiation studies on clays from Pindiga Formation in Northeastern Nigeria and were able to present requirements for each of the clay samples studied to attains its optimum rheology (Fig. 2).

But even with the attainment of their optimum rheological properties and satisfying the standard required for use in oil and gas well drilling, these properties were only measured under ambient temperature while the reality when it comes to applying these treated/beneficiated clays under field condition could be entirely different. This study therefore sets out to study the physical and other properties (Loss On Ignition, Specific Gravity, Particle Size Distribution, Textural Classification and Formulated Cation Exchange Capacity) of the sample were already determined and compared with API grade sample, behavior of three of these clay earlier studied by Arabi et al., 2017 at different temperature that could be met in the field (down-hole condition). The clays chosen for this study are PNG, GHZ and SGN, they were chosen because they constitute the best-behaved clays among the ones studied earlier. Other detail on earlier studies on the samples and others has been reported in Arabi et al., 2017.

1.1. *Geology and stratigraphy of the study area*

The clay samples PNG, GHZ and SGN (inset Fig. 3) were from different locations around Pindiga, Garin Hamza and Sabon Garin Ngalda Towns within the Benue Trough in Northeastern Nigeria. The samples are from Pindiga Formation. This formation was first studied by Barber et al. (1954) and later named "Pindiga Formation" by Carter et al., 1963. 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.

A type-section from Pindiga stream (southwestern part of Gombe (Fig. 3) shows that, it is a thick shaly sequence with intercalations of limestone and some fossils. The stratigraphic sequence of the study area begins with granitoids of the Basement Complex (Precambrian), the feldspathic sandstones, sandy clay (Bima Sandstone), shales, shelly limestone (Yolde Formation), shale and limestone of marine facies, (Pindiga Formation), non-marine facies (Gombe Sandstone), grits, sand and clays (Kerri-Kerri Formation), Tertiary to Recent volcanics, Chad Formation, and alluvium (Fig. 4). Other details on the geology and rheological studies on this Formation and other samples from and outside the study area can be found in Zaborski, 1998, Bilal et al., 2015, 2016a, 2016b, Arabi et al., 2011, 2012, 2017, and Dewu et al., 2011a; Dewu et al., 2011b.