Characterisation of Iron Ore from Opon Mansi in Ghana and its Potential as a Weighting Agent in a Water-Based Mud

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Abstract

Oil and gas resources are in deeper formations, and drilling into such formations necessitates the use of well-designed drilling mud with appropriate rheological qualities to prevent or minimise related drilling issues. Therefore, mud engineers utilise additives or chemicals to alter drilling mud properties to achieve the desired results for drilling. This study sought to characterise iron ore from Opon Manso in Ghana and assess its potential as a weighting agent in water-based mud. X-Ray Diffractometer, X-Ray Fluorescence (XRF) and specific gravity tests were conducted to characterise the iron ore. The standard procedures recommended by API RP13B-1 were followed to determine the density, rheological properties as well as fluid loss of the formulated samples. Separate drilling muds were formulated by varying the concentration of iron ore and barite to attain the same mud weight ranging between 9.0 ppg to 13 ppg at 77 ^{0}F (25 ^{0}C) and 104 ^{0}F (40 ^{0}C). The results showed that the Opon Mansi iron ore contains FeOOH (Goethite) which is a hydrous form of hematite (Fe_2O_3) with lower specific gravity compared with the imported barite. The pH of the iron ore (hematite) mud samples decreased with increasing mud weight while that of barite mud samples increased with increasing mud weight. The rheological values of the hematite were higher than that of imported barite and produced a higher filtrate and thicker mud cake.

Keywords: Apparent Viscosity, Barite, Hematite, Plastic Viscosity, Yield Point

1 Introduction

A major element of a successful drilling operation is the performance of the drilling mud in the wellbore. To some great extent, the cost and success of drilling operations are linked to the drilling mud properties. Drilling mud is a combination of clay and additives, with the base fluid being either water or oil (Al-Hameedi et al., 2019; Kania et al., 2015; Okorie, 2009). It is circulated in the wellbore to carry out drilling activities that would be cost-effective and efficient. Some of these activities include the removal of cuttings, cooling and lubricating the drill string and bits, balancing the formation pressures in the wellbore, and transmitting hydraulic power to the bit, among others (Kwaw and Broni-Bediako, 2022; Gandhi and Sarkar, 2006; Abdulkadir et al., 2013). The cost of the drilling mud in the overall cost of a drilling project is estimated to be about 15% of the budget (Anon, 2022a). According to Gamal et al. (Gamal et al., 2019), drilling fluid cost is about 25-40% of the total cost of the drilling operation. Therefore, drilling mud must be carefully designed and formulated to avoid any drilling challenges and ensure efficient drilling operations. Controlling the properties of drilling mud is key to keeping it efficient for reaching targets.

Several types of additives or chemicals are used to modify the drilling mud properties to meet wellbore conditions (Al-Yasiri and Al-Sallami, 2015). The most common type of drilling mud additives is viscosifiers, lost circulation materials, surfactants, and weighting agents (materials), among others. Weighting agents play a critical role in assisting mud engineers to change fluid density to be able to withstand high formation pressures to prevent kicks and possible blowouts of the wellbore (Apkabio et al., 2015). Weighting agents also play a vital role in cementing operations. It helps in controlling the settling and gelation of cement slurry, preventing strength retrogression, and reducing the permeability of the cement sheath. Barite is the most recommended material for increasing the density of drilling fluids, though there are other weighting materials such as galena, calcium carbonates, ilmenite, micromax, micro manganese, and hematite (Apkabio et al., 2015; Bageri et al., 2021; Fadl et al., 2020; Basfar et al., 2020; Ma et al., 2019). All the recognised weighting agents used in drilling fluid and cement slurry formation in Ghana are imported, which increases the overall drilling cost. To improve upon the viability of a petroleum project in Ghana requires the search for local materials which can equally perform a similar function as the imported materials and are cost-effective as compared to the imported materials. The search for local materials will sustain the petroleum industry in Ghana which is capital-intensive. It will, in no doubt, provide home-based technological advancement, significant

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logistical improvement, substantial cost saving, and overall, help meet up with the local content aspiration (Broni-Bediako et al., 2015).

Ghana is endowed with mineral deposits. Much attention has been given to the exploitation of minerals such as gold, bauxite, diamond, and manganese as compared to other minerals like iron. The potential iron ore deposits in Ghana include Opon Mansi iron ore, the Pudo iron ore, Sheini Iron Ore, and among others. Iron deposits occur in the form of hematite, magnetite, and among others. The Opon Mansi iron ore is situated on top of a range that extends over about 15 miles (24 km) from Opon – Valley in the Western Region. The hill on which the iron ore occurs has an average height of about 400 m and the largest and highest is 450 m above sea level (Kesse, 1985). These iron deposits could serve as a source of minerals for iron-making and weighting agents for drilling and cementing operations. Hence this research sought to characterise iron ore from Opon Mani in Ghana and assess its potential as a weighting agent in a Water Based Mud (WBM).

2 Materials and Methods

2.1 Materials

The materials used to conduct the experiment were bentonite, iron ore, barite, and fresh water. The rocky iron ore was obtained from the Opon Mansi iron ore deposit in the Western Region of Ghana. The rocky samples (Fig. 1) were first crushed with a hammer into smaller particles (Fig. 2) before it was further crushed by a cone crusher. Samples from the cone crusher were milled (Fig. 3) such that 2 500 g was milled in a ball mill for 2 hours to produce pulverized samples that were passed through a 0.25 mm or 250 µm sieve size (Fig. 4).

Fig. 1 Rocky Samples

Fig. 2 Hammer-Crushed Sample

Fig. 3 Cone Crushed Sample

Fig. 4 Pulverized Sample

2.2 Methods

This section focuses on the various methods employed in the iron ore characterisation, mud preparation, pH, density, rheology, and filtration determination.

2.2.1 Iron Ore Characterisation

The various minerals present in the pulverised iron ore were determined and analysed using X-Ray Diffractometer (XRD). XRD method is an excellent non-destructive analytical technique employed in the phase identification of a crystalline material in the form of a solid or powder (Zaidi and Sitepu, 2011). It allows a known wavelength of X-rays to pass through a sample to identify the chemical composition, physical properties, and crystal structure (Atiemo, 2012). The elemental composition of the pulverised iron ore from Opon Mansi was determined using a non-destructive analytical technique called X-ray fluorescence spectroscopy (XRF) (Agorhom, 2018). The specific gravity of the powdered samples (iron ore and barite) was determined using Equation 1.

$$Sg = \frac{w_2 - w_1}{(w_4 - w_1) - (w_3 - w_2)} \quad (1)$$

Where, Sg=Specific gravity, w_1=weight of the container, w_2=weight of the container + dry sample, w_3=weight of container + dry sample +water and w_4= weight of container + water

2.2.2 Drilling Mud Preparation

The drilling mud samples for the study were formulated following the standard laboratory practices recommended by American Petroleum Institute (API RP13B-1). An electronic mass balance was used to measure the weight of the freshwater, bentonite, and weighting agents (barite or iron ore). Bentonite, fresh water, and the weighting agents were blended using Chandler Engineering Model 3260 constant-speed mixer to obtain a homogenous mixture of the formulated mud. The weighting agents were varied to obtain the required weight ranging from 9.00 ppg to 13.00 ppg. Table 1 shows the quantities of materials used in the drilling mud formulation.

Table 1 Composition of Drilling Mud Samples

Material (g)	Sample A	Sample B	Sample C
Fresh Water	350.0	350.0	350.0
Bentonite	22.5	22.5	22.5
Iron Ore	20.0	165.0	320.0
Barite	25.0	150.0	295.0

2.2.3 Density Test

Mud density is used to control subsurface pressures and stabilize the wellbore. Drilling mud density must always be monitored and controlled during drilling operations to prevent drilling problems such as kicks, loss of circulation, and differential pressure pipe sticking among others (Khaled et al., 2019). The density of all the formulated mud samples was determined right after each sample was prepared using Bariod mud balance.

2.2.4 Hydrogen Ion Concentration (pH) Test

Each of the samples was allowed to age for a minimum of sixteen (16) hours before any test was conducted. Aging is a process where drilling fluids previously exposed to a time of shear are permitted to develop their rheological and filtration properties more fully (Makinde et al., 2011). The aging of drilling fluid helps to simulate the properties of drilling fluid at bottom-hole conditions to get a genuine picture of the bottom-hole conditions instead of using surface conditions or properties (Olise et al., 2017). After the aging period, the samples were vigorously stirred and poured into a beaker and tested using a pH meter.

2.2.5 Rheology Test

Rheology indicates a drilling fluid's flow and deformation characteristics under external forces. It provides important information required in the design of circulating systems (Dankwa et al., 2018). The significance of the study of rheology could be seen in the analysis of fluid flow velocity profiles, and fluid viscosity (Xu et al., 2018; Broni-Bediako and Amorin, 2019). In this study, plastic viscosity, yield point, apparent viscosity, and gel strength of the mud samples were determined. The Fann viscometer was used to derive various dial readings of the rheological properties of all samples at varying speeds (600, 300, 200, 100, 6, and 3 rpm) as recommended by the API. The Plastic Viscosity (PV), Yield Point (YP), and Apparent Viscosity (AV) were calculated from Equations 2, 3, and 4 respectively (Abdou et al., 2018).

$$PV = \Theta_{600} - \Theta_{300}, \text{(cP)} \quad (2)$$

$$YP, = \Theta_{300} - PV, \text{(Ib/100 ft}^2) \quad (3)$$

$$AV = \Theta_{600}/2, \text{(cP)} \quad (4)$$

Where cP = Centipoise, lb = barrel, ft = feet, Θ_{600} and Θ_{300} are dial readings at 600 rpm and 300 rpm respectively.

2.2.7 Filtration and Filter Cake Test

The loss of liquid from mud due to filtration is controlled by the filter cake formed from the solid constituents in the drilling fluid (Shabarudin, 2013). Proper control of filtration can minimise wall sticking and drag, and in some areas improve wellbore stability. Separate mud samples containing the iron ore (hematite) and barite were tested for filtration and filter cake thickness. A static filtration test was carried out at room temperature and a pressure of 100 psi produced from a carbon cartridge. The volume of filtrates produced from the mud samples were collected and recorded from a graduated cylinder within 30 minutes. The rate at which fluid from a mud sample is forced through a filter and the thickness of the solid residue (filter cake) were measured. The thickness of the filter cake was obtained using a vernier calliper.

3. Results and Discussion

3.1 Characterisation of the Opon Mansi Iron Ore

Fig. 5 shows the result obtained from the XRD analysis of the iron ore. From the XRD results the Opon Mansi iron ore contains FeOOH (Goethite) which is a hydrous form of Hematite (Fe_2O_3), illustrated as 2FeOOH ≡ $Fe_2O_3.H_2O$. All the peaks show hydrous Hematite (FeOOH). The dominant compound was the hydrous hematite which shows the highest peaks with an intensity (Arbitrary units) of 14 350. Table 2 shows the results obtained from the XRF results of the analysis of the sample of the Opon Mansi iron ore. From the XRF results in Table 2, the ore contains Aluminium Oxide (Al_2O_3) with a weight percent of 9.774, Silicon Oxide (SiO_2) of 7.273, Magnesium Oxide (MgO) 1.242, and among others. The dominant element was Hematite (Fe_2O_3) with a weight percent of 75.204. The Loss on Ignition (L.O.I) was low at about 4.660 wt% which signifies that the ore contained low volatile materials.

Table 3 shows the results of the specific gravity test of the iron ore (hematite) and barite. The iron ore from Opon Mansi had a specific gravity of 3.62 compared to 4.13 of the commercial barite. This indicates that the locally sourced hematite is less dense as compared to barite and therefore, more hematite would be required to design and formulate the same weight of drilling mud (fluid) as compared to barite.

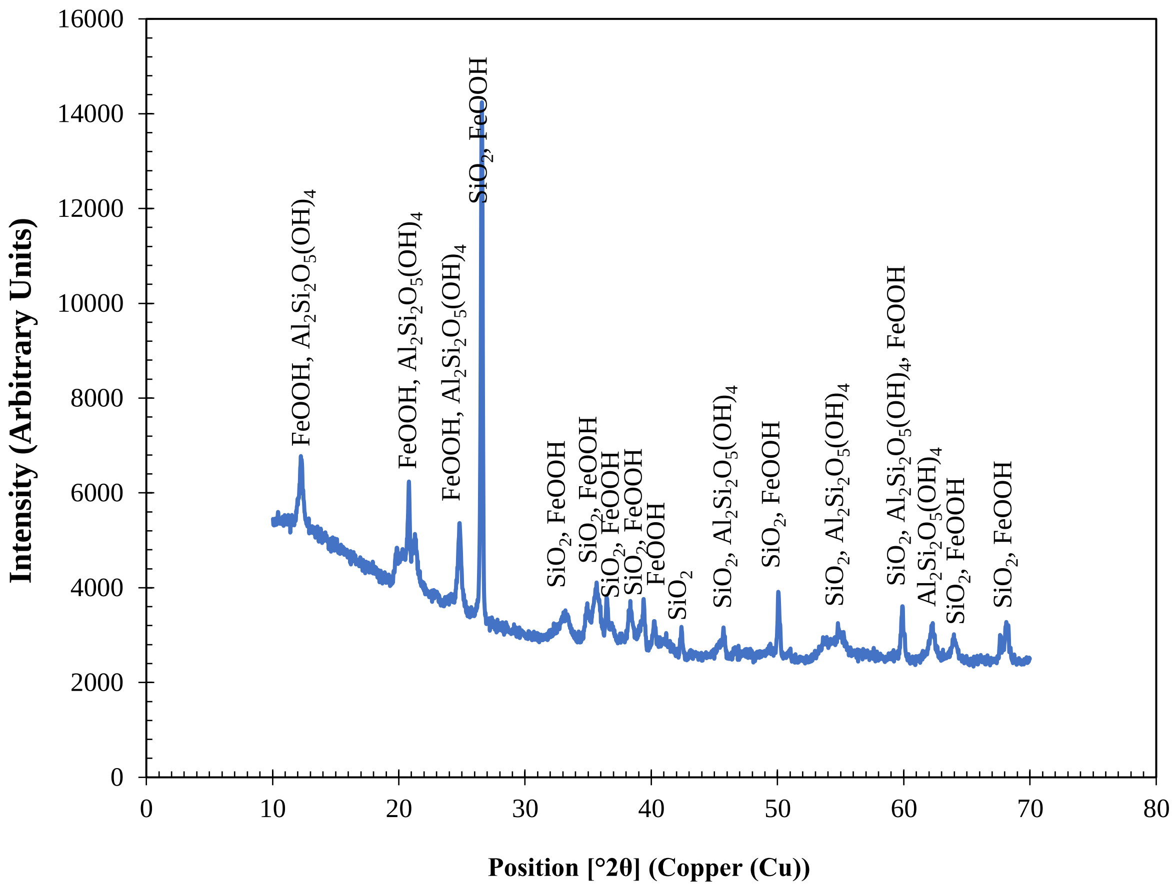

Fig. 5 X-Ray Diffractogram of the Opon Mansi Iron Ore

Table 2 XRF Results of the Opon Mansi Iron Ore

Component	Composition (wt%)
Na_2O	-
MgO	1.242
Al_2O_3	9.774
SiO_2	7.273
P_2O_5	0.723
SO_3	0.107
K_2O	0.141
CaO	0.124
TiO_2	0.476
V_2O_5	0.007
Cr_2O_3	0.025
MnO	0.222
Fe_2O_3	75.204
NiO	0
CuO	0
ZnO	0
SrO	0.0025
ZrO_2	0.0107
Rb_2O	0.0045
Nb_2O_5	0
U_3O_8	0.0046
L.O.I.	4.660
Sum	**100.00**

Table 3 Results of Specific Gravity (Sg) of the Hematite and Barite

	A	B	C	D	E	F
Container	**Hematite**			**Barite**		
w_1	34.1	29	32.4	31.8	32.9	31.6
w_2	50	46.3	49.1	47.1	51.1	48.1
w_3	92.5	88.2	94	89.8	92.2	93
w4	81	75.6	82	78.2	78.4	80.5
Sg	3.61	3.68	3.55	4.14	4.14	4.13
Average Sg	**3.62**			**4.13**		

3.2 pH of Mud Samples

The pH of drilling mud is one of the vital parameters that determine its performance. Drilling mud performs well with a pH range of 8.0 to 10.5 for water-based mud (Aremu et al., 2017). The mix-water (freshwater) used in the formulation of the drilling fluid had an average pH of 7.4. The pH of all the mud samples was in the range of 8.70 - 10.17. This suggests that the mud samples were not acidic and would therefore not result in pitting and corrosion. The pH of the mud mixed with barite increased with an increased density as compared with mud samples mixed with hematite, which decreased with density (Table 4).

Table 4 pH Test Results

Density (ppg)	pH of Mud	
	Barite	**Hematite**
9	9.72	8.70
11	10.27	7.51
13	10.17	7.13

3.3 Rheological Properties

The experiment was conducted at 77 ^{0}F (25 ^{0}C), and 104 ^{0}F (40 ^{0}C) to determine the rheological properties of WBM formulated with barite and locally sourced hematite. The results are shown in Table 5.

Table 5 Rheological Values for Hematite and Barite Mud Samples at Varying Mud Weights

Dial Reading	77 ^{0}F	104 ^{0}F	77 ^{0}F	104 ^{0}F	77 ^{0}F	104 ^{0}F
	Hematite					
	9 ppg		**11 ppg**		**13 ppg**	
600 rmp	28	26	73	109	173	228
300 rmp	19	17	60	97	149	211
200 rmp	15	14	55	95	141	209
100 rmp	11	11	49	94	131	208
6 rmp	5	5	40	87	118	202
3 rmp	4	4	38	82	111	175
PV (cP)	9	9	13	12	24	17
AV (cP)	14	13	36.5	51.5	86.5	114
YP (lb/100 ft^2)	10	8	47	85	125	194
10’ Gel (lb/100 ft^2)	7	9	51	73	115	144
10’’ Gel (lb/100 ft^2)	20	25	76	99	167	155
	Barite					
	9 ppg		**11 ppg**		**13 ppg**	
600 rmp	34	33	56	59	65	70
300 rmp	23	22	43	46	49	55
200 rmp	17	19	38	40	44	48
100 rmp	13	14	31	36	40	45
6 rmp	6	10	22	32	27	38
3 rmp	4	4	19	27	26	34
PV (cP)	11	11	13	13	16	15
AV (cP)	17	16.5	28	29.5	32.5	35
YP (lb/100 ft^2)	12	11	30	33	33	40
10’ Gel (lb/100 ft^2)	7	14	25	34	33	38
10’’ Gel (lb/100 ft^2)	23	28	45	66	57	104

3.3.1 Plastic Viscosity and Mud Weight

Plastic Viscosity (PV) is the measure of the flow resistance offered by a fluid. The resistance is because of friction between the liquid undergoing deformation under shear stress and the solids and liquids present in the drilling mud (Anon, 2022b; Khaled et al., 2019). Figs. 6 and 7 show the relationship between plastic viscosity and mud weight at 77 ^{0}F (25 ^{0}C) and 104 ^{0}F (40 ^{0}C) respectively. Figs. 6 and 7 show that PV increases with increasing mud weight. This follows a similar trend revealed by Anon in 1995. According to Anon (1995), the PV of mud increases as mud density is increased, by the addition of barite or hematite (more solids). Fig. 6 shows that at 9 ppg, the barite mud sample recorded higher PV than hematite. This situation is due to the difference in the specific gravity of the weighting agents. The barite used had high gravity (SG = 4.13) compared to the hematite (SG = 3.62). As the density of the mud samples was increased to 11 ppg at 77 ^{0}F (25 ^{0}C), the hematite and barite mud samples had the same PV. However, at 13 ppg, the hematite mud sample recorded a higher PV than the barite mud sample. The phenomenon is due to the amount of hematite used to formulate the 13 ppg mud (Table 5). Increasing the amount of hematite due to its low specific gravity resulted in more solids being introduced into the mud thereby resulting in higher PV. At a temperature of 77 ^{0}F (25 ^{0}C), a mud weight of 13 ppg resulted in a PV of 24 cP for the hematite mud sample compared to the barite mud sample with a PV of 16 cP. As the temperature increased to 104 ^{0}F (40 ^{0}C) (Fig. 7), the plastic viscosity of both weighting materials had a similar trend. At 9 ppg, hematite had a lower plastic viscosity value compared to barite, that is 9 cP and 11 cP respectively. As the mud weight was increased to 13 ppg, the locally sourced hematite recorded a PV of 17 cP while barite had a plastic viscosity of 15 cP. It was observed that at higher temperatures, the plastic viscosity values of both samples decreased. This is because PV is a function of the viscosity of the fluid phase of the mud and as temperature rises, the viscosity of water decreases, and the PV will decrease (Shabarudin, 2013).

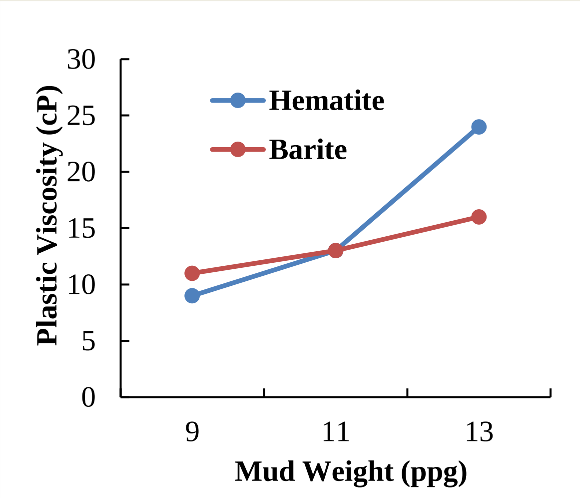

Fig. 6 Plastic Viscosity against Mud Weight at 77 ^{0}F (25 ^{0}C)

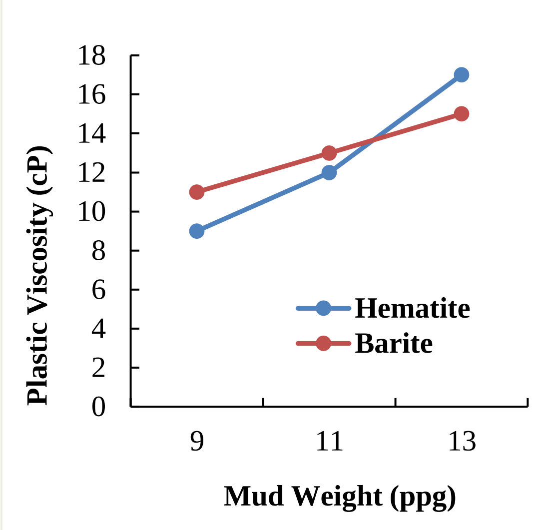

Fig. 7 Plastic Viscosity against Mud Weight at 104 ^{0}F (40 ^{0}C)

3.3.2 Yield Point and Mud Weight

Figs. 8 and 9 are the relationship between yield point and mud density at both 77 ^{0}F (25 ^{0}C) and 104 ^{0}F (40 ^{0}C) respectively. The Yield Point (YP) is the maximum stress that a solid can withstand without undergoing permanent deformation either by plastic flow or rupture [10]. It plays a vital role in hole cleaning. Higher YP exhibits good carrying capacity for mud solids and formation cuttings [8]. The result shows that the hematite mud sample has a higher yield point than the barite mud sample at mud weight of 11 ppg and 13 ppg. As the temperature increased from (77 ^{0}F) 25 ^{0}C to 104 ^{0}F (40 ^{0}C), the yield point values of both samples increased. This behaviour is an indication of the presence of inert solids in both drilling mud systems. The higher values recorded in the hematite mud system are because more hematite (Table 1) was used to obtain the same mud weight as that of the barite mud sample. At 77 ^{0}F (25 ^{0}C), the hematite mud sample at a weight of 9 ppg and 13 ppg had plastic viscosity values of 10 lb/100 ft^2 and 125 lb/100 ft^2 respectively and the barite mud sample at the same weight recorded 12 lb/100 ft^2 and 33 lb/100 ft^2 respectively (Fig. 8). Similarly, at 104 ^{0}F (40 ^{0}C), a mud weight of 9 ppg and 13 ppg hematite had plastic viscosity values of 8 lb/100 ft^2 and 194 lb/100 ft^2 respectively and barite recorded a yield point value of 11 lb/100 ft^2 and 40 lb/100 ft^2 respectively (Fig. 9).

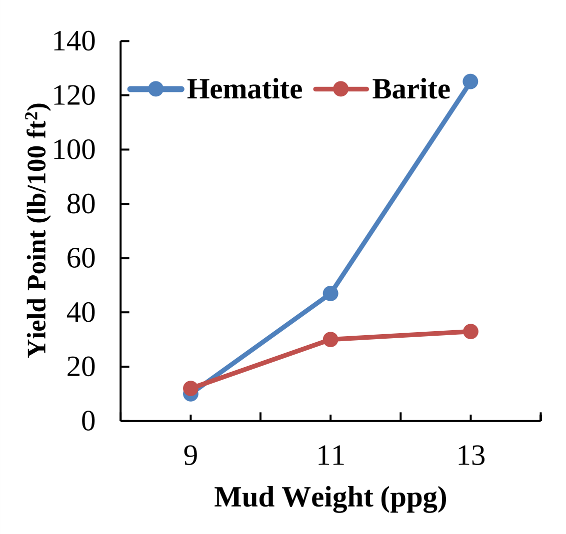

Fig. 8 Yield Point against Mud Weight at 77 ^{0}F (25 ^{0}C)

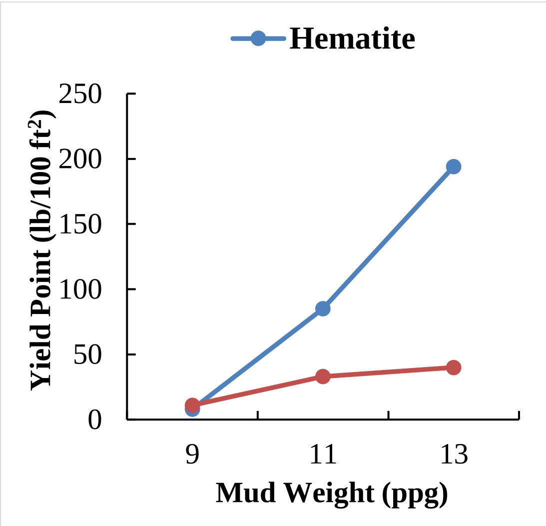

Fig. 9 Yield Point against Mud Weight at 104 ^{0}F (40 ^{0}C)

3.3.3 Apparent Viscosity and Mud Weight

The apparent viscosity plot for both drilling mud at 25 ^{0}C (Fig. 10) and 40 ^{0}C (Fig. 11), had similar patterns as the plastic viscosity and yield point when the weight (density) of the mud samples were increased from 9 ppg to 13 ppg. For a mud weight of 9 ppg at 25 ^{0}C, the locally sourced hematite had a lower apparent viscosity value of 14 cP compared to that of barite, 17 cP. However, as the mud weight increased to 11 ppg and 13 ppg, it was seen that the hematite mud sample had a higher apparent viscosity, that is 36.5 cP and 86.5 cP respectively compared to the barite mud samples which recorded 28 cP and 32.5 cP respectively. The increase in apparent viscosity is attributed to the quantity of hematite used to make the various mud weights.

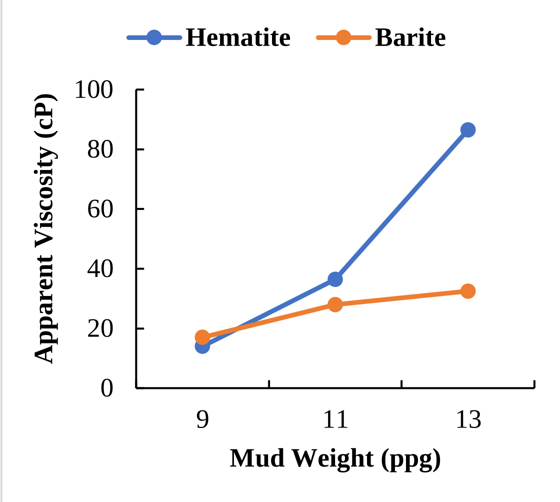

Fig. 10 Apparent Viscosity against Mud Weight at 77 ^{0}F (25 ^{0}C)

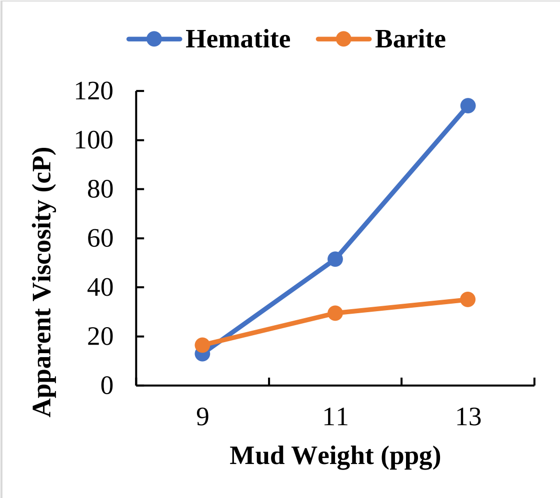

Fig. 11 Apparent Viscosity against Mud Weight at 104 ^{0}F (40 ^{0}C)

3.3.4 Gel Strength and Mud Weight

The gel strength of drilling fluid is the measure of the shearing stress necessary to initiate a finite rate of shear. An initial 10-second gel and a 10- minute gel strength measurement indicate the amount of gelation that will occur after circulation ceased and the mud remains static. The more mud gels during shutdown periods, the more pump pressure will be required to initiate circulation again (Shabarudin, 2013). The 10' gel strength plot of both samples at 77 ^{0}F (25 ^{0}C) and 104 ^{0}F (40 ^{0}C) shows a similar trend. At 77 ^{0}F (25 ^{0}C), the hematite mud sample had a gel strength of 7 lb/100 ft^2 and 115 lb/100 ft^2 for 9 ppg and 13 ppg mud weight respectively (Fig. 4.8) and that of the barite mud sample at the same temperature and mud weight was 7 lb/100 ft^2 and 33 lb/100 ft^2 respectively. At 104 ^{0}F (40 ^{0}C) both hematite and barite had their 10-second gel strength values increased to 144 lb/100 ft^2 and 38 lb/100 ft^2

respectively at a mud weight of 13 ppg (Fig. 4.9).

The 10-minute gel strength plot shows that over time, the gel strength of both samples increases and as well increases with increasing temperature. At 77 ^{0}F (25 ^{0}C) with a mud weight of 13 ppg, hematite and barite recorded a gel strength of 167 lb/100 ft^2 and 57 lb/100 ft^2. At 104 ^{0}F (40 ^{0}C), hematite and barite values increased at a mud weight of 13 ppg, recording gel strength values of 155 lb/100 ft^2 and 104 lb/100 ft^2 respectively.

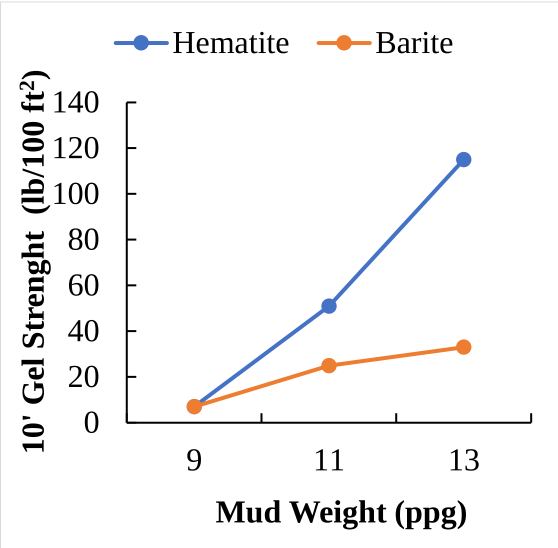

Fig. 12 10-Second Strength against Mud Weight at 77 ^{0}F (25 ^{0}C)

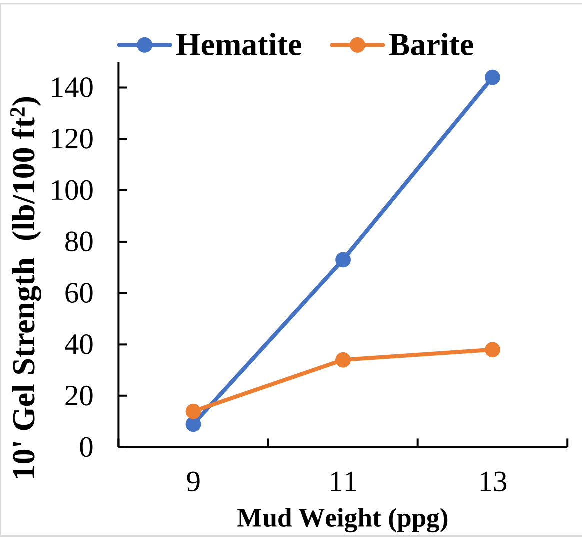

Fig. 13 10-SecondStrength against Mud Weight at 104 ^{0}F (40 ^{0}C)

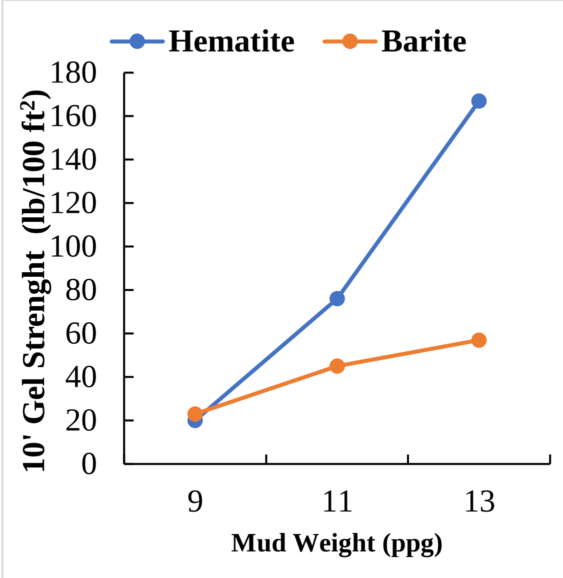

Fig. 14 10-Minute Gel Strength against Mud Weight at 77 ^{0}F (25 ^{0}C)

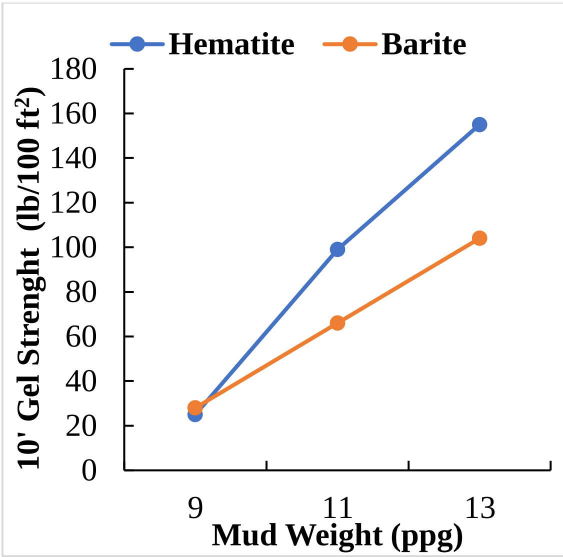

Fig. 15 10-Minute Gel Strength against Mud Weight at 104 ^{0}F (40 ^{0}C)

3.4 Filtration

The filtration test is to determine the volume of water that penetrates the formation from the mud during the drilling process under varying bottom-hole conditions. Low fluid loss is an indication of good drilling mud, and this is imperative to the integrity of the wellbore. In addition, a good drilling mud should have a thin mud cake to prevent excessive loss of fluids into the formation (Broni-Bediako and Amorin, 2019; Nasser et al., 2013). Fig. 16 shows the results of the filtration test for both weighting materials. From Fig. 16, hematite recorded the highest volume of filtrate at every mud weight compared to the filtrate produced by barite mud samples. For example, at 9 ppg, the highest filtrate for both hematite and barite were recorded as 13.6 ml and 11 ml respectively at 30 mins, an increase of 2.6 ml for the hematite mud sample. At 13 ppg, the mud samples recorded filter values of 18.4 ml and 16.6 ml respectively for hematite and barite which is 1.8 ml more than the filtrate produced by the barite mud sample. In addition, the hematite mud samples formed thicker mud cakes compared to barite at all the various mud weights. For example, at 9 ppg, the locally sourced hematite recorded a mud cake thickness of 3 mm while barite recorded 2 mm, and at 13 ppg, hematite recorded 10 mm while barite recorded 4 mm (Fig. 17). The higher values recorded by hematite is due to the quantity of hematite used to formulate the same mud weight produced by barite. As more hematite was introduced to achieve the required weight, more solids were introduced into the mud system which increased the filter values and the thickness of the filter cakes.

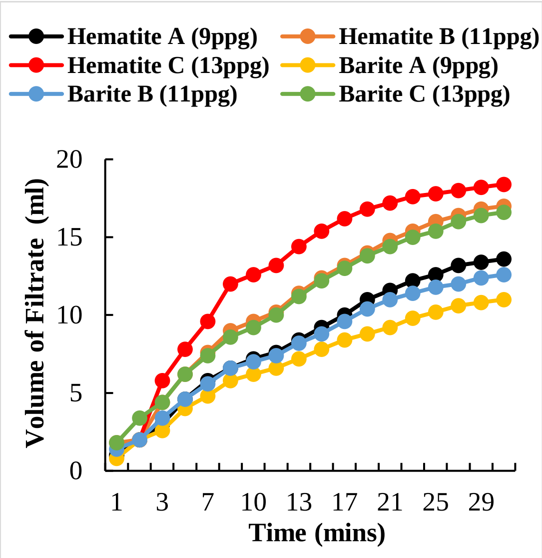

Fig. 16 Filtrate against Time

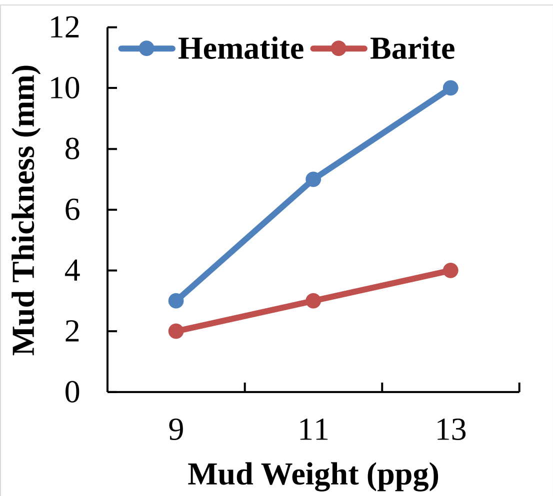

Fig. 17 Mud Thickness against Mud Weight

4 Conclusions

This study investigated the possibility of using iron ore from Opon Manso in Ghana as a weighting agent in water-based mud. The X-Ray Diffractometer, X-Ray Fluorescence (XRF) and specific gravity test were conducted to characterise the iron ore and the standard procedures recommended by API RP13B-1 were followed to determine the density, rheological properties and fluid loss of the formulated mud samples containing hematite. The characterisation analysis showed that the predominant mineral contained in iron ore was FeOOH (Goethite) which is a hydrous form of hematite (Fe_2O_3) with about 75% by weight. The average specific gravity of hematite was 3.62 which makes it less dense compared to barite which has a specific gravity of 4.13. The pH value of hematite decreases with increasing mud weight while that of barite increases with increasing mud weight. The rheological values of locally sourced hematite were higher than that of commercial barite. Hematite produced a higher filtrate and thicker mud cake compared to barite.

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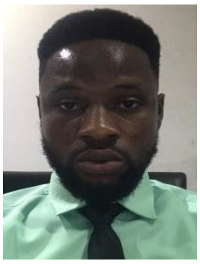

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