الإستهلال

قال تعالى في محكم تنزيله:

بسم الله الرحمن الرحيم

﴿لَقَدْ أَرْسَلْنَا رُسُلَنَا بِالْبَيِّنَاتِ وَأَنزَلْنَا مَعَهُمُ الْكِتَابَ وَالْمِيزَانَ لِيَقُومَ النَّاسُ بِالْقِسْطِ ۖ وَأَنزَلْنَا الْحَدِيدَ فِيهِ بَأْسٌ شَدِيدٌ وَمَنَافِعُ لِلنَّاسِ وَلِيَعْلَمَ اللَّهُ مَن يَنصُرُهُ وَرُسُلَهُ بِالْغَيْبِ ۚ إِنَّ اللَّهَ قَوِيٌّ عَزِيزٌ﴾ (25)

صدق الله العظيم

سورة ﴿الحديد﴾

Deduction

To cheer up our hearts with their meeting
To gardens of love which grows the best flower
Our mothers…
To the symbols of Manhood and sacrifice in our life's
To who pushed us to science and we're proud by it
Our fathers…
To those closest to us more than our souls
To those join us mother's lap
Our brothers & sisters…
To those who accompanied us in our study and join our worries
Memorial and Tribute
Our friends…
To the scientific edifice and a beacon of science and knowledge
Sudan University of science and technology
Thank you, Lord, for always being there for us.
To all of you..
We dedicate this research.

Acknowledgment

In the name of Allah, most gracious, and most merciful praise be almighty Allah who gave us the courage and energy to complete this research. We have to thank **our parents** for their help and support throughout my life, thank you both for giving us strength to reach our dreams. We would like to sincerely thanks **our supervisor**,

Dr: Youssef Eltahir Bagadi, for his guidance and support throughout this research, and especially for his confidence in us.

Special thanks for **Dr: Abdelhakam** for his support, and **Dr: Abdelmunim** from EL Neelain university who's supporting us for sample collection.

We would like also to thanks **Eng. Ali Mamoun** for serving as a member on our committee, his comments and advice which is very beneficial in our completion of the manuscript and especially at first discussion. Our thanks and gratitude to **everyone who help us** from near or a far to complete this work and in overcoming the difficulties encountered, most notably.

Eng. Dalia Salih, who spared us, guidance and advice in drilling fluid laboratory.

And we don't forget to thank **Eng**. **Rami Ahmed** from Ministry of Minerals.

Deep thanks extended to this great edifice **Sudan University of Science and technology** and special thanks to **college of Petroleum engineering and technology**.

Abstract

Bentonite is main component of drilling fluids, used in drilling oil and gas wells, our target and objectives is to explore and evaluate the local bentonite for Abuhasheem Mountain in northern state and Mahatta Mountain in river Nile state in Sudan. Bentonite is montmorillonite and is volcanic origin, from commercial standpoint there are two primary types of natural bentonite sodium and calcium. Sodium bentonite is characterized by its ability to absorb large amount of water and form viscous, thixotropic suspensions. Calcium bentonite in contrast is characterized by its low water absorption and swelling capabilities and its inability to stay suspended in water. Each type of bentonite has its own unique application and is known as the clay of other uses. Our process begins with exploration local bentonite for Abuhasheem and Mahatta mountains. Clay samples are collected and sent to central petroleum laboratory (CPL) for XRD test, criminal evidence laboratory for XRF test and Drilling fluids lab in college of petroleum engineering for measurements properties of clay. The samples were collected and sent to the central petroleum laboratory for XRD test , the sample were then sent to the criminal laboratories for XRF test , the sample were then sent to laboratory test in college of petroleum engineering and technology to measure properties of the samples, A standard bentonite was added to the samples and the properties were measured to evaluate the quality of bentonite.

التجريد

في هذا البحث تم استكشاف وتقييم البنتونايت المحلي لجبل ابو هشيم في الولاية الشمالية ثم جبل المحطة في ولاية نهر النيل, حيث ان البنتونايت هو من المكونات الرئيسية لسوائل الحفر والمستخدم في حفر ابار النفط والغاز وهوعبارة عن منتوموليرات المكونة من الرماد البركاني ومن وجهة نظر تجارية هناك نوعين من البنتونايت المستخدم وهما: صوديوم بنتونايت وكالسيوم بنتونايت, حيث ان الصوديوم بنتونايت يتميز بقدرته العالية على امتصاص المياه وقدرته على البقاء معلقا في الماء, اما الكالسيوم بنتونايت امتصاصه للماء منخفض وكذلك قدرته على البقاء معلقا في الماء, ولكلا النوعين خصائص و تطبيقات فريدة , وكذلك للبنتونايت استخدامات اخرى, بدأت العمليات باستكشاف البنتونايت للمنطقتين وتم جمع العينات وارسالها الى مركز الابحاث النفطية لاجراء الاختبارات الاشعاعية ثم ارسلت العينات الى معامل الادلة الجنائية لتحليل نسب العناصر في العينات ثم تم اجراء اختبارات معملية في مختبر كلية هندسة وتكنولوجيا النفط بجامعة السودان للعلوم والتكنولوجيا لقياس الخصائص التيارية للعينات ,ثم تم اضافة بنتونايت قياسي الى العينات وتم قياس الخصائص بغرض تقييم جودة العينات

Table of Contents:

List of Figures:

List of Tables:

Nomenclature:

A:	Contact area
AC:	Alternating Current
API:	American Petroleum Institute
CMC:	Carboxy Methyl Cellulose
CP:	centipoise
$CO2$:	Carbon Dioxide
DB:	Barite Density
DW:	Water Density
KCl:	potassium chloride
XRF:	X-ray fluorescence analysis
XRD:	X-ray powder diffraction
TGA:	thermal gravimetric analysis
ppg:	pounds per gallon
Psi:	pounds per square inch
$R600$:	is the dial reading at 600 r/min
rpm:	Rotation per minute
SG:	Specific Gravity
SPIF:	sulfonated phenol and formaldehyde
SUST Lab:	Laboratory of Sudan University of Science and Technology
TC:	Temperature Coefficient
USC units:	United States customary *units*
VB :	Volume of Barite required

VS :	Volume of Silicat
Vw :	Volume of Water required
WBM :	water based mud drilling fluid
YP :	Yield Point
g:	gram per mille liter
$kg/m3$:	Kilogram per cubic meter
$lb/$:	pounds per gallon
$lb/ft3$:	pounds per cubic feet
$ml/30$:	mille liter per thirty minutes

Chapter1: Introduction

Chapter: 1

Introduction

1.1. Introduction:

• The most important challenge for the oil industry in the Sudan at these days especially with the drop in oil prices in the world it is to reduce the cost of importing drilling fluids additives.

• In this project our aim to benefit from the mineral wealth represented by bentonite clay for its importance in drilling fluids.

• Bentonite is added to fresh water or fresh-water muds for one or more of the following purposes:

1. To increase hole cleaning capability;

2. To reduce water seepage or filtration into permeable formation;

3. To form a thin, low permeability filter cake;

4. To promote hole stability in poorly cemented formation, and

5. To avoid or overcome loss of circulation.Attapulgite is another quietly different family of clay mineral which can be used as viscosifiers in water based muds

1.2. Problem Statement:

The problem that the project is trying to solve is high drilling fluid cost and price of oil and gas product is low. This problems comes from:

- No Investigation and research of local bentonite clay
- Cost of drilling fluids additives`
- Local bentonite is available but not used

1.3. Objective of the Study:

- beneficiation of local bentonite
- Evaluation local bentonite quality with standard specification (API)

1.4. Methodology:

1- Gathering data by:

a) Geological data

b) Clay properties data

c) Laboratory data

2- Exploration of location:

a) Mahatta mountain

b) Abuhasheem mountain

3- Analysis of samples

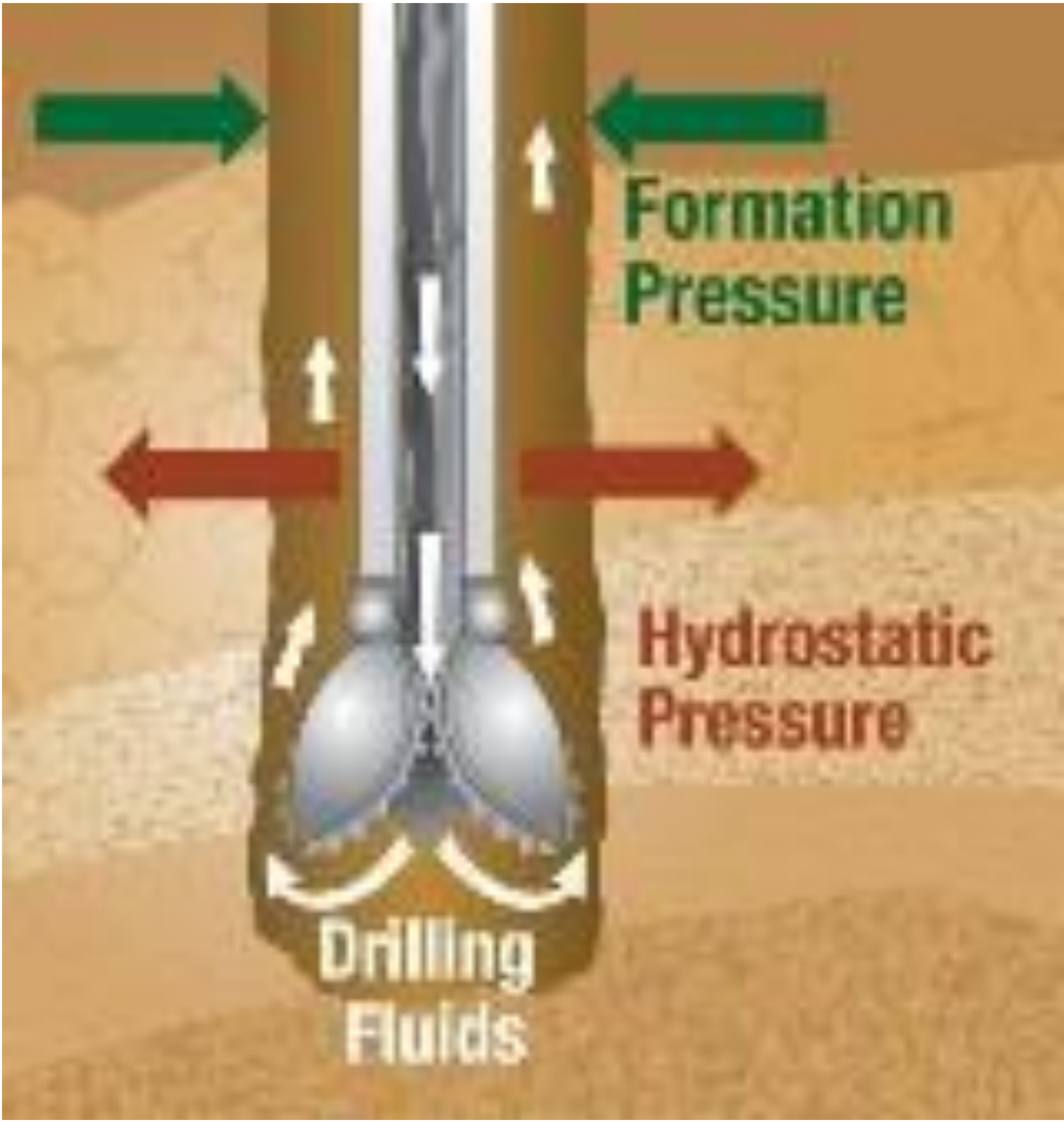
4- Comparison between samples

1.5 Thesis Outlines:

Chapter two of this thesis comprises literature review, drilling fluids background, Water based mud background and Properties, while chapter three consists of Laboratory tests procedure, and chapter four consists of results and discussion, lastly Chapter five consists of conclusion and recommendation.

Chapter2:

Literature review and Background Theoretical



Chapter: 2

Literature review and theoretical Background

2.1. Literature Review:

G.M. Bol, Koninklijke/Shell E&P Laboratories 1991, Bentonite Quality and Quality-Evaluation Methods Differences in rheology and fluid loss between bentonite suspensions in fresh water, seawater, and hydrogen peroxide(H 20 2) solutions give a quantitative measure of bentonite extension. Differences in performance before and after hot-rolling do the same.

Emad S Alhomadhi 2007 improving local bentonite performance for drilling fluid application based on above result and can compete with the imported bentonite.

M.I. Abdou, A.M. Alsabagh, M.M. Dardir 2013 the Nano-bentonite was characterized by X-ray fluorescence analysis (XRF), X-ray powder diffraction (XRD), thermal gravimetric analysis (TGA) and Transmission electron the evaluation involved the study of the rheological properties, filtration and gel strength before and after treatment with viscosities and filter loss agent.

Abu Sabah Elfateih 2013 Study effect of adding a local bentonite in fluids properties Um Ali Mountain. Recommended use of treated local bentonite in different fields of drilling engineering Satisfy API specification.

2.2. Drilling Fluids Background:

Drilling fluid or also called drilling mud is a mixture of water, oil, clay and various chemicals. Within drilling it performs various functions and contributes with a large portion to the total well costs. In this way the mud system (or mud program) has to be carefully designed to ensure a successful drilling project. The objective of a drilling operation is to drill, evaluate and complete a well that will produce oil and/or gas efficiently. Drilling fluids perform numerous functions that help make this possible. The responsibility for performing these functions is held jointly by the mud engineer and those who direct the drilling operation. The duty of those charged with drilling the hole including the oil company representative, drilling contractor and rig crew is to make sure correct drilling procedures are conducted. The chief duty of the mud engineer is to assure that mud properties are correct for the specific drilling environment. The mud engineer should also recommend drilling practice changes that will help reach the drilling objectives.

2.2.1. Drilling Fluid Functions:

Drilling fluid functions describe tasks which the drilling fluid is capable of Performing, although some may not be essential on every well. Removing cuttings from the well and controlling formation pressures are of primary importance on every well. Though the order of importance is determined by well conditions and current operations, the most common drilling fluid functions are:

1. Remove cuttings from the well.
2. Control formation pressures.
3. Suspend and release cuttings.
4. Seal permeable formations.
5. Maintain wellbore stability.
6. Minimize reservoir damage.

7. Cool, lubricate, and support the bit and drilling assembly.
8. Transmit hydraulic energy to tools and bit.
9. Ensure adequate formation evaluation.
10. Control corrosion.
11. Facilitate cementing and completion.
12. Minimize impact on the environment

2.2.2. Drilling Fluid Selection:

Many different types of water-base drilling fluid systems (muds) are used in drilling operations. Basic drilling fluid systems are usually converted to more complex systems as a well is deepened and the wellbore temperature and/or pressure increases. It is typical for several types of drilling fluid systems to be used in each well. Several key factors affect the selection of drilling fluid system(s) for a specific well.

The following requirements and criteria should be applied when considering the selection of drilling fluid or fluids for a particular well. It should be noted that it is common to utilize two or three different fluid types on one well.

1. Pore pressure /fracture gradient plots to establish the minimum / maximum mud weights to be used on the whole well.

2. Offset well data (drilling completion reports, mud recaps, mud logs etc.) from similar wells in the area to help establish successful mud systems, problematic formations, and potential hazards, estimated drilling time etc.

3. Geological plot of the prognosis lithology.

4. Casing design to give each casing point and the casing program. This will give a good indication of what the mud has to deal with per hole section i.e. formation type, hole size and length etc.

5. Basic mud properties required over each section.

6. Note any possible restriction that might be enforced i.e. Government

Legislation in the area.

2.3. Water Based Mud Background:

The term water-base mud refers to any drilling fluid where the continuous phase, in which some materials are in suspension and others are dissolved, is water. The water may be fresh, brackish or seawater. Thus any water-base mud system consists of a water phase, inert solids, a reactive solids phase and chemical additives. Each of these parts contributes to the overall mud properties.

The following designations are normally used to define the classifications of water based drilling fluids:

I. Inhibitive water-base Mud –Calcium Muds:

When swelling and hydration of clays and shales are expected, inhibitive water-base muds can be applied. Calcium muds are best suited to penetrate horizons that contain gypsum and hydrite. A sub classification of inhibitive water-base muds distinguishes seawater muds, saturated saltwater muds, lime muds and gypsum muds.

ii. Dispersed Muds –Lignosulphonate Muds:

Dispersed muds are used when the mud has to have following characteristics: relative high mud weight (larger than 14 [ppg]), used at moderately high formation temperatures, low filtration loss required and high tolerance for contamination by drilling solids.

Some of the disadvantages when using dispersed muds are: heaving of shales and causing formation damage due to dispersant of formation clays in the presence of lignosulphonate.

Dispersed mud systems consist of: fresh or salty water, bentonite, lignosulphonate, caustic soda and colloidal polymers (carboxy methyl cellulose 'CMC' or stabilized starch). In general, these mud systems exhibit better control of viscosity, a higher solids tolerance and a better control of filtration than non-dispersed muds.

iii. Non dispersed Muds –KCL/Polymer Muds:

To drill water sensitive and sloughing shales such as productive sands which are prone to formation damage, fresh water nondispersed muds are applied. Commonly, nondispersed muds are associated with low mud weights and low solid concentrations.

Nondispersed mud systems consist of: fresh water or brine, potassium chloride (KCl), inhibiting polymer, viscosifier, stabilized starch or carboxy methyl cellulose, caustic soda and lubricant

iv. Flocculated Muds:

Flocculated muds possess generally a dynamic increase in filtration, viscosity and gel strength. Flocculation refers to a thickening of the mud due to edge-to-edge and edge-to-face association of clay particles. The flocculation is commonly caused by high active solids concentration, high electrolyte concentration and high temperature. To reduce the flocculating tendency of the mud, chemical additives, also called deflocculates or thinners are used.

Thinners like phosphates, tannins, lignin and lignosulphonate are applied to lower the yield point and gel strength. When deflocculates are added, the PH value is controlled by NaOH.

v. Salt-saturated Muds:

Salt-saturated muds are used to drill through salt domes and salt sections, these mud systems are saturated with sodium chloride ($NaCl$) that prevents severe hole enlargements due to washouts of the salt formations. Swelling of bentonite shales is controlled by adding of polymer.

2.4. Drilling Fluid Additives in WBM:

There are many drilling fluid additives which are used to either change the mud weight (density) or change its chemical properties.

The variety of fluid additives the complexity of mud systems currently in use. The complexity is also increasing daily as more difficult and challenging drilling conditions are encountered. Indeed, it would be easy to write several volumes on mud types and mud additives. We shall limit ourselves to the most common types of additives used in water-based mud.

2.4.1. Weighting materials or densifiers:

Are solid materials which when dissolved or suspended in water; will increase the mud weight. Some examples of weighting materials are barite, hematite, calcium carbonate and galena.

2.4.2. Viscosifiers:

Are materials used to increase the viscosity of drilling mud to make it able to suspend drill cuttings and weighting materials. Without viscosity, all the weighting material and drill cuttings would settle to the bottom of the hole as soon as circulation is stopped.

They are several types of clays available that are used as viscosifiers. But the most widely used clay in oil industry is bentonite.

Bentonite is added to fresh water or fresh-water muds for one or more of the following purposes;

1. To increase hole cleaning capability.

2. To reduce water seepage or filtration into permeable formation.

3. To form a thin, low permeability filter cake.

4. To promote hole stability in poorly cemented formation.

5. To avoid or overcome loss of circulation.

Attapulgite is another quietly different family of clay mineral which can be used as viscosifiers in water based muds. Attapulgite-based muds have excellent viscosity and yield strength and retain these properties when mixed with salt water. However, they have the disadvantage of suffering high water loss thereby giving poor sealing properties across porous and permeable formations.

Polymers are used as viscosifiers and also used for filtration control, flocculation and shale stabilization. Clays may be entirely replaced by polymers when drilling water sensitive shales or water producing zone. Some examples of polymers used as additives in drilling mud make up are: Starches, Guar Gum, Xanthan Gum (Microbial Polysaccharides), Carboxy methylcellulose (CMC), Polyanionic Cellulose (PAC) and Hydroxyethyl Cellulose (HEC).

2.4.3. Filtration control materials:

Are compounds which reduce the amount of fluid that will be lost from the drilling fluid into a subsurface formation caused by the differential pressure between the hydrostatic pressure of the fluid and the formation pressure. Bentonite, polymers and thinners or deflocculants all function as filtration control agents.

2.4.4. Lubricating materials:

Are used mainly to reduce friction between the wellbore and the drill string.

Lubricating materials include: oil (diesel, mineral, animal, or vegetable oils), surfactants, graphite, asphalt, gilsonite, polymer and glass beads.

2.5. Drilling Fluid Properties

The properties of a drilling fluid can be analyzed by its physical and chemical attributes. The major properties of the fluid should be established in the mud program. Each mud property contributes to the character of the fluid and must be monitored regularly to show trends, which can be used to ascertain what is happening to the mud whilst drilling and show any problems the fluid is experiencing. Addition of treating chemicals are added in concentrations, i.e. pound per barrel (ppb). Many chemicals have primary and secondary effects on the mud system.

The most important drilling fluid properties are listed below.

2.5.1. Density: pounds/gallon (lb/gal)

The density (commonly referred to as mud weight) is measured with a mud balance of sufficient accuracy. For all practical purposes, density means weight per unit volume and is measured by weighing the mud. The weight of mud may be expressed as a hydrostatic pressure gradient in $lb/in2\ per\ 1{,}000\ ft$ of vertical depth ($psi/1{,}000\ ft$), as a density in lb/gal, $lb/ft3$ or Specific Gravity (SG).

2.5.2. Plastic Viscosity: centipoise (cps)

The plastic viscosity () is calculated by measuring the shear rate and stress of the fluid. These values are derived by using a Fann viscometer.

2.5.3. Yield Point: $lbs/100ft2$

This parameter is also obtained from the viscometer. The yield point (YP) is a measure of the electro-chemical attractive forces within the mud under flowing conditions. The yield point is the shear stress at zero shear rate.

2.5.4. Gel Strength: $lbs/100ft2$ ($10sec/10min$)

This is a measurement that denotes the thixotropic properties of the mud and is a measurement of the attractive forces of the mud while at rest or under static conditions. Gel strength is measured with the viscometer.

2.6. Bentonite Quality:

Bentonite quality determined mainly by three parameters:

1-The content of material other than montmorillonite.

2-The type of content _ions presents on the montmorillonite platelets.

3-The size and charge of montmorillonite platelets.

Pure bentonite should contain only meant because of declining reserves of high quality bentonite, other mineral such as ileitis, kaolinite and chlorites.

Chapter: 3

Exploration of local Bentonite and Laboratory Experiments

Chapter: 3

Exploration of local Bentonite and Laboratory Experiments

3.1. Introduction:

This chapter contains a detailed description of locations and experiments,

Which measure and estimate Rheological properties of drilling fluid, and the description contains (clarify measurement principle, devices used, the tests are carried out on each drilling fluid is prepared and how the testing process achieved.

3.2. Description of locations:

The samples of this research were collected from Abuhasheem and Mahatta mountains in the north of the Sudan.

Abuhasheem435Km north of Khartoum capital of Sudan and defined by coordinates N: 16^0 40′27.8″E: $31^0$30′ 56″.

Mahatta 248km north of Khartoum capital of Sudan and defined coordinates N: $17^0$02′47.3″E: 33^0 42′36″.

Sample has been carried out by using hummer.

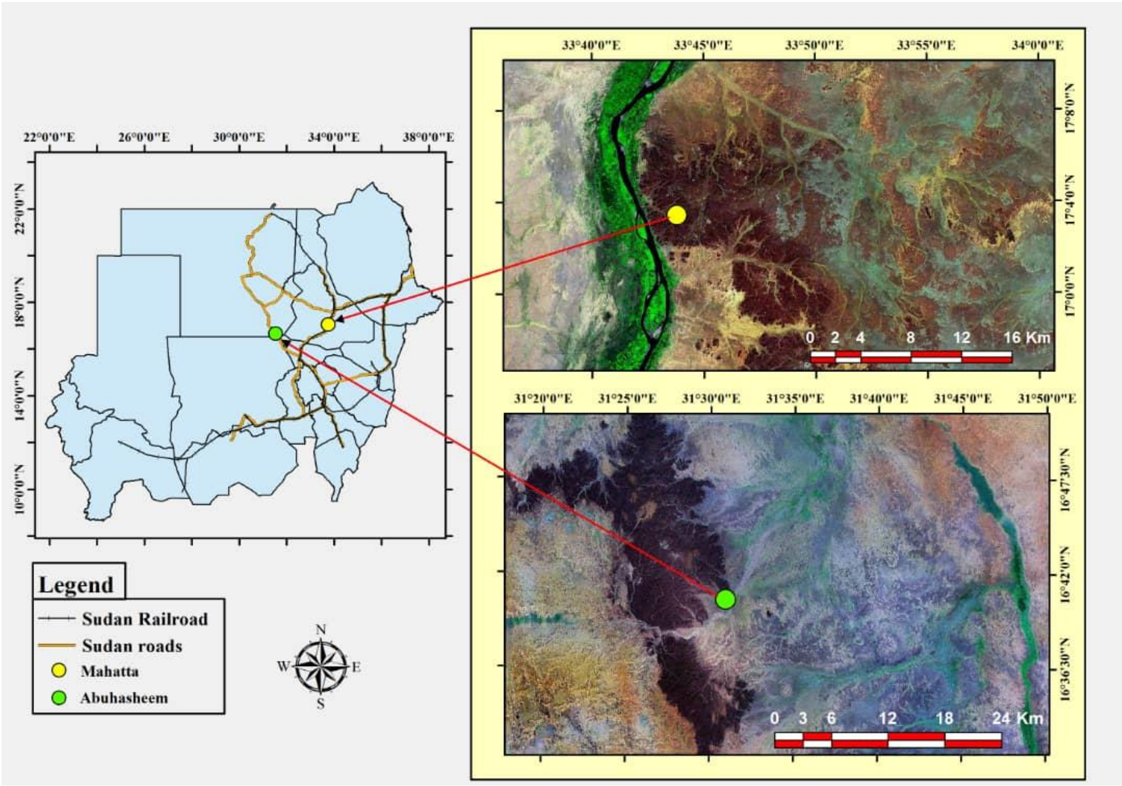


Figure (3-1) Abuhasheem and Mahatta study area

3.3. Description of Equipment's:

3.3.1. Rtesch crusher:

Particle size distribution by sieve analysis, sample was carried out for particle size and raw sample were dried in oven at 100°c for 4hr then were crushed used Rtesch crusher (**RS200**) the powder was sieved by using **75** micron as opening mesh.

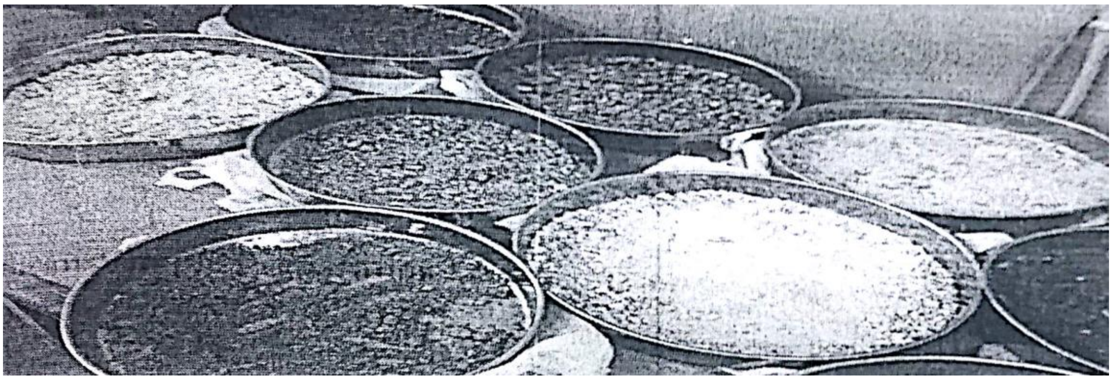


Figure (3-2) sieve analysis

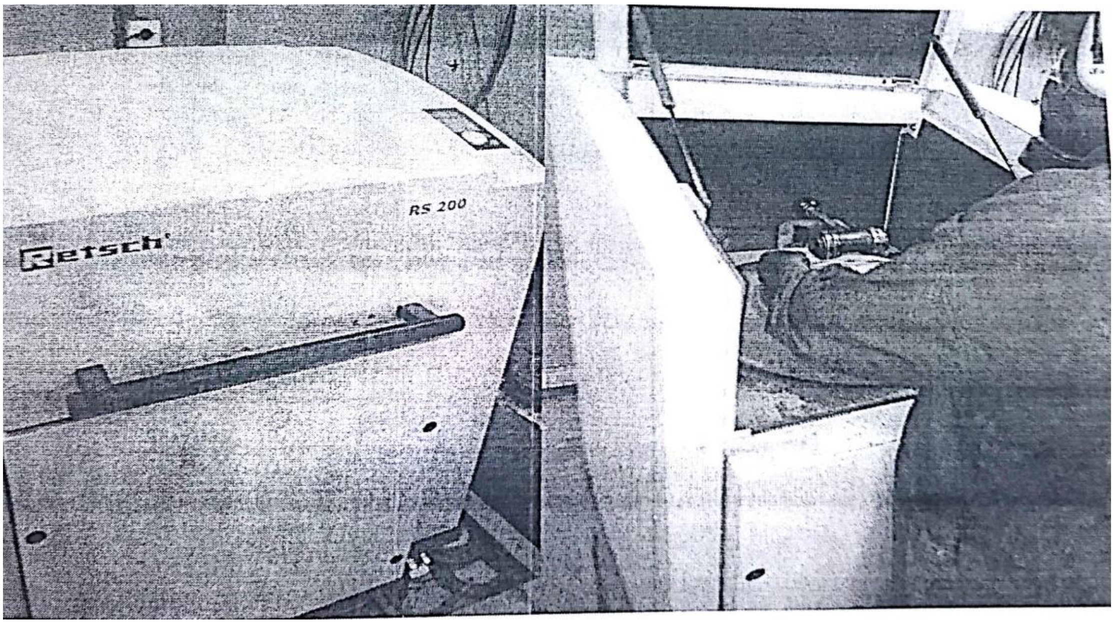


Figure (3-3) RS-200 Crusher

3.3.2. Digital Balance:

The digital balance is the instrument used for weighing solid materials, as illustrated in figure below:

Fig. (3-4) Digital balance

3.3.3. Mud Mixer

The mud mixer is the instrument used for mixing the mud components. As shown in fig. (3-5) the mud mixer consist mainly from crank connected to an electric motor and fan to stir the component.

Fig. (3-5) Mud mixer

3.3.4. Mud Balance:

The mud balance is the instrument generally used for drilling-fluid density determinations. Fig. (3-13) illustrate that the mud balance is designed such that the drilling-fluid holding cup, at one end of the beam, is balanced by a fixed counterweight at the other end, with a sliding-weight rider free to move along a graduated scale. A level-bubble is mounted on the beam to allow for accurate balancing. Attachments for extending the range of the balance may be used when necessary.

The instrument should be calibrated frequently with fresh water. Fresh water should give a reading of 1.00 g ml or 1000 kg/m3 (8.33 lb/gal or 62.3lb/ft3) at 21 °C (70 °F). If it does not, adjust the balancing screw or the amount of lead shot in the well at the end of the graduated arm as required.

Fig. (3-6) Mud balance

3.3.5. Six speed viscometer:

This type of viscometer is a rotational instrument powered by an electric motor or a hand crank. Drilling fluid is contained in the annular space between two concentric cylinders. The outer cylinder or rotor sleeve is driven at a constant rotational velocity. The rotation of the rotor sleeve in the fluid produces a torque on the inner cylinder or bob. A torsion spring restrains the movement of the bob, and a dial attached to the bob indicates displacement of the bob.

Instrument constants have been adjusted so that plastic viscosity and yield point are obtained by using readings from rotor sleeve speeds of 300 r/min and 600 r/min

Fig. (3-7) Six Speed Viscometer

3.3.6. API Filter Press:

As shown in fig. (3-15), API filter press consisting mainly of a cylindrical drilling-fluid cell having an inside diameter of 76.2 mm (3 in) and a height of at least 64.0 mm (2.5 in). This cell is made of materials resistant to strongly alkaline solutions and is so fitted that a pressure medium can be conveniently admitted into, and bled from, the top. It shall also be fitted such that a sheet of 90 mm (3.54 in) diameter filter paper can be placed in the bottom of the cell just above a suitable support. The filtration area is (45.8 ± 0.6) cm^2 [(7.1 ± 0.1) in^2]. Below the support is a drain tube for discharging the filtrate into a graduated cylinder. Sealing is accomplished with gaskets and the entire assembly supported by a stand. Pressure can be applied with any non-hazardous fluid medium. Pressures are equipped with pressure regulators and can be obtained with portable pressure cylinders, midget pressure cartridges or means for utilizing hydraulic pressure. To obtain correlative results, one thickness of the proper 90 mm diameter filter paper shall be used.

Fig. (3-8) API-filter-press

3.3.7. PH Analysis:

The pH of an aqueous solution (water based) is a number that .indicates the nature of the solution as acidic, neutral or basic

- PH < 7: The solution is acidic
- PH = 7: The solution is neutral
- Psolution is basic H > 7: The

Fig. (3-9) PH Analysis

3.3.8. XRD Device:

X-ray diffraction is a unique method in determination of crystallinity of a compound.

Fig. (3-10) XRD Device

3.3.9 XRF Device

X-ray fluorescence is the emission of characteristic from a material that has been excited by bombarding with high energy X-ray or Gama ray.

The phenomenon is widely used for elemental analysis and chemical analysis.

Fig. (3-11) XRF Device

3.4. Preparation of Mud:

To prepare any drilling fluid; you must follow the following steps

1. Fill the cup by the specified quantity of water.
2. Then, weight of the solids to be added.
3. Turn on the mud mixer to stir the water inside.
4. Add solids gradually according to quantities measured previously.
5. Waiting period (5hours) until mixture becomes homogeneous

3.5. Tests Procedures:

It is necessary to perform certain tests to determine if the mud is in proper condition to perform the functions previously discussed. The frequency of these tests will vary in particular areas depending upon conditions.

Tests procedures performed according to **API** recommendation.

3.5.1. Mud Density Test Procedure:

1. Set the instrument base on a flat, level surface.

2. Fill the clean, dry cup with drilling fluid to be tested; put the cap on the filled drilling-fluid holding cup and rotate the cap until it is firmly seated. Ensure that some of the drilling fluid is expelled through the hole in the cap in order to free any trapped air or gas.

3 Holding the cap firmly on the drilling-fluid holding cup (with cap hole covered), wash or wipe the outside of the cup clean and dry.

4. Place the beam on the base support and balance it by moving the rider along the graduated scale. Balance is achieved when the bubble is under the centerline.

5. Read the drilling fluid density from one of the four calibrated scales on the arrow side of the sliding weight. The density can be read directly in units of $g\ \ ml$, $lb\ \ gal$, and $lb/ft3$, or as a drilling fluid gradient in $psi\ 1000ft$.

3.5.2. Rheological Properties Test Procedure:

1. Place the sample in a container and immerse the rotor sleeve exactly to the scribed line. Measurements in the field should be made with minimum delay (within 5 min, if possible).

2. With the sleeve rotating at $600\ \ r/min$, wait for viscometer dial reading to reach a steady value (the time required is dependent on the drilling-fluid characteristics). Record the dial reading for $600\ r/min$.

3. Reduce the rotor speed to 300 r/min and wait for the viscometer dial reading to reach a steady value. Record the dial reading for $300\ r/min$.

4. Stir drilling fluid sample for $10\ s\ at\ 600\ r/min$. Stop the rotor.

5. Allow drilling fluid sample to stand undisturbed for 10 s slowly and steadily turn the hand-wheel in the appropriate direction to produce a positive dial reading. The maximum reading is the initial gel strength. For instruments having a speed of $3\ \ r/min$, the maximum reading attained after starting rotation at $3\ r/min$ is the initial gel strength.

6. Record the initial gel strength $10\ -\ second\ \ gel\ \ in\ \ pounds\ \ per\ \ 100ft2$.

7. Re-stir the drilling fluid sample at $600\ \ r\ \ \min\ \ for\ \ 10s$, stop the rotor and allow the drilling fluid to stand undisturbed for 10 min. repeat the measurements as in 3.5and report the maximum reading as the $10\ \ -$ $minute\ gel\ in\ pounds\ per\ 100\ ft2$.

8. Calculate the Apparent Viscosity (AV), Plastic Viscosity (PV), Yield Point (YP), Power Low Index (N) and Consistency Index (K) by using the following equations:

Both Plastic Viscosity (PV) and Yield Point (YP) are mathematical values which can be used for calculating the pressure loss in the circulating system as: when plastic viscosity rises, this is usually an indication that the solids control equipment are running inefficiently. Ideally, the yield point ηp should be just high enough to suspend the cuttings as they are circulated up the annulus.

The calculation for the plastic viscosity expressed in millipascal seconds (centipoise), is given in Equation (3.1):

$$\eta p = R600 - R300 \qquad (3.1)$$

Where:

$R600$ is the dial reading at 600 r/min.

$R300$ is the dial reading at 300 r/min.

NOTE 1:

The plastic viscosity is commonly known in the industry by the abbreviation PV.

NOTE 2:

$1\ cp = 1\ mpa.s.$

The calculation for the yield point YP, expressed in pascals, is given in Equation (3.2):

$YP, A = 0.48 \times R300 - \eta$ (3.2)

When calculating values in USC units, the yield point (expressed in pounds per one hundred square feet) is calculated as follows:

$YP, = R300 - \eta$ (3.3)

NOTE: The yield point, expressed in pounds per one hundred square feet, is commonly known in the industry by the abbreviation.

The other rheological properties can be calculated from the following equations:

Apparent Viscosity:

$$(AV) = R600/\ 2 \quad (3.4)$$

Gel strength:

$$(GS)= R3@10sec\ R3@10mi \quad (3.5)$$

Non-Newtonian (power law) Index:

(n)=3.32×log $(R600/R300)$ (3.6)

Consistency Index :(k) $= R300/\ (511^{n})$ (3.7)

Chapter 4:

Results and Discussion

4. Results and Discussion

4.1. Results:

As described in earlier chapters, several laboratory investigation have been carried out on this research work. The investigation have been conducted for the collected samples (Abuhasheem and Mahatta site area). Table from 4.1 to 4. Show summary of results which indicates the following:

a) Percentage of bentonite
b) Percentage of component in bentonite
c) Mud properties
d) Rheological properties
e) Mixed pure collected samples with API standard bentonite**.**

4.1.1. XRD Analysis:

An XRD analysis was performed for Abuhasheem and Mahatta

Table (4-1) samples to determine percentage of bentonite and kaolinite.

Table (4.1): **Percent of Bentonite and Kaolinite in samples.**

No	Sample Code	Kaolinite 2θ=12.3	Bentonite 2θ=5.4
1	Abuhasheem	23.46	76.54
2	Mahatta	56.97	43.03

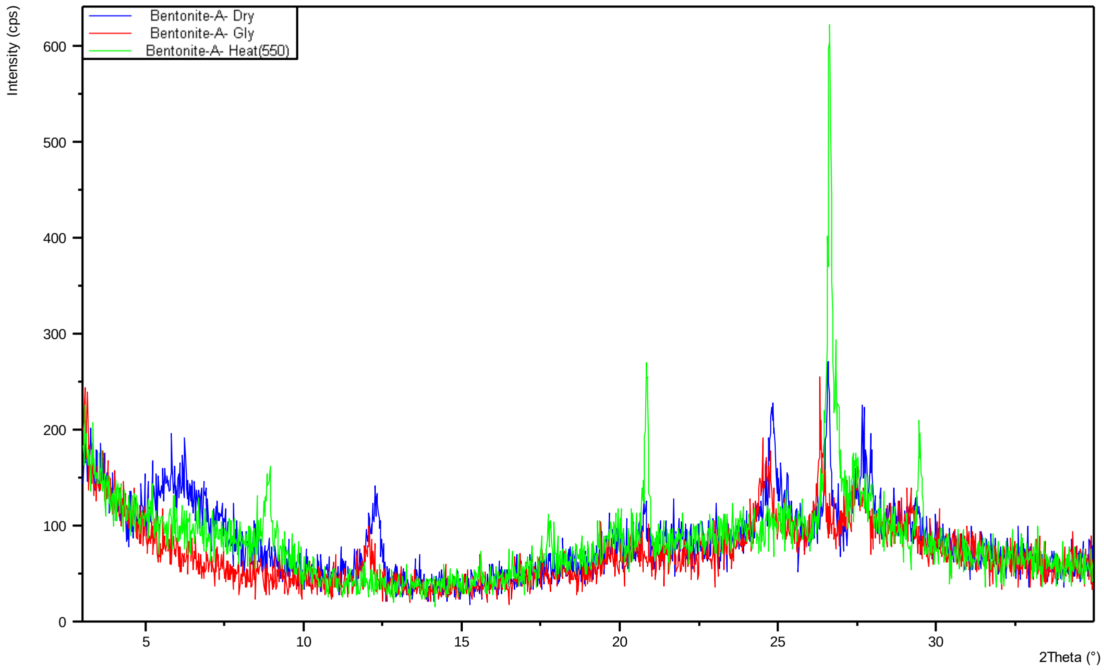


Fig. (4-1) XRD Analysis for Abuhasheem Mountain

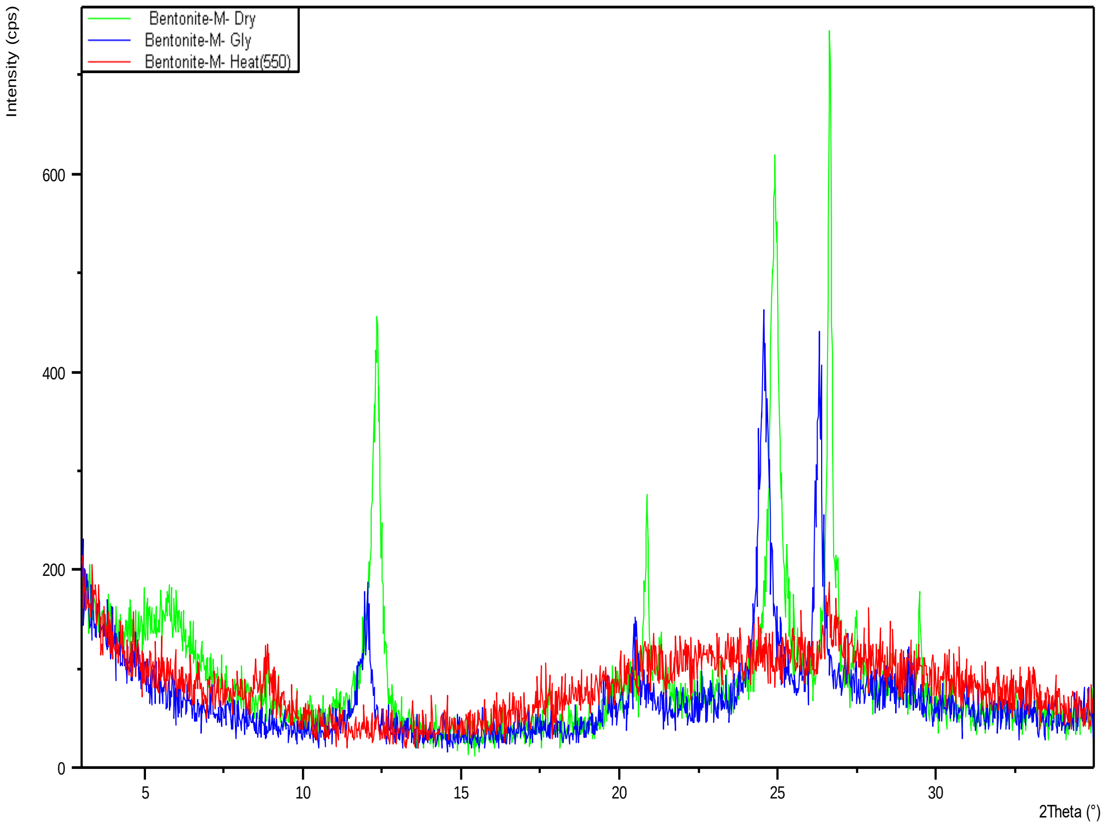


Fig. (4-2) XRD Analysis for Mahatta Mountain4.2. XRF Analysis:

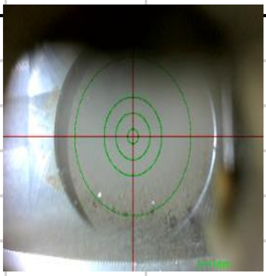
Table (4.2) consist of Abuhasheem clay per percentages for components.

Table (4.2) Abuhasheem XRF test (%)

XRF Report

Sample Information

Sample Name	Abuhasheem
Meas. Date	2018/10/15 17:48:49
Comment	Quick&easy Air-Metal
Group	detail
Operator	



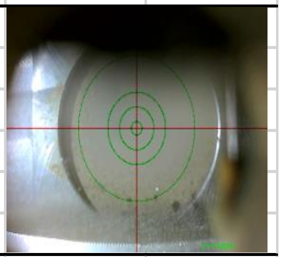
Quantitative Result

Analyte	Result		Std.Dev.	Calc.Proc	Line	Intensity
Si	43.951	%	[0.770]	Quan-FP	SiKa	6.5112
Fe	24.831	%	[0.065]	Quan-FP	FeKa	429.8421
Al	14.807	%	[0.712]	Quan-FP	AlKa	0.7919
Ca	9.383	%	[0.098]	Quan-FP	CaKa	17.9709
Ti	2.924	%	[0.060]	Quan-FP	TiKa	34.5136
K	2.509	%	[0.046]	Quan-FP	K Ka	1.1648
S	0.761	%	[0.123]	Quan-FP	S Ka	0.0377
Mn	0.304	%	[0.008]	Quan-FP	MnKa	3.4709
V	0.133	%	[0.022]	Quan-FP	V Ka	2.3507
Zr	0.133	%	[0.005]	Quan-FP	ZrKa	18.0812
Sr	0.112	%	[0.005]	Quan-FP	SrKa	14.0863
Zn	0.045	%	[0.002]	Quan-FP	ZnKa	0.1053
Cu	0.040	%	[0.007]	Quan-FP	CuKa	1.8531
Cr	0.035	%	[0.007]	Quan-FP	CrKa	0.3074
Ir	0.027	%	[0.003]	Quan-FP	IrLa	0.0394
Br	0.005	%	[0.001]	Quan-FP	BrKa	0.0480

Table (4.3) consist of Mahatta clay per percentages for components.

Table (4.3) Mahatta XRF test (%)

Sample Information							
Sample Name	Mahatta						
Meas. Date	2018/10/15 18:58:33						
Comment	Quick&easy Air-Metal						
Group	detail						
Operator							



Quantitative Result							
Analyte	Result			Std.Dev.	Calc.Proc	Line	Intensity
Si	52.424	%		[0.794]	Quan-FP	SiKa	7.6741
Al	20.284	%		[0.744]	Quan-FP	AlKa	1.2368
Fe	20.162	%		[0.054]	Quan-FP	FeKa	404.2480
Ti	2.709	%		[0.053]	Quan-FP	TiKa	36.5241
K	2.518	%		[0.046]	Quan-FP	K Ka	1.0842
Cl	0.615	%		[0.063]	Quan-FP	ClKa	0.0665
Ca	0.401	%		[0.015]	Quan-FP	CaKa	0.7465
S	0.365	%		[0.047]	Quan-FP	S Ka	0.2061
Zr	0.151	%		[0.003]	Quan-FP	ZrKa	25.0569
V	0.136	%		[0.019]	Quan-FP	V Ka	2.7414
Mn	0.064	%		[0.006]	Quan-FP	MnKa	0.8433
Cr	0.056	%		[0.007]	Quan-FP	CrKa	0.5630
Sr	0.031	%		[0.003]	Quan-FP	SrKa	4.7910
Ir	0.028	%		[0.003]	Quan-FP	IrLa	0.0486
Zn	0.025	%		[0.001]	Quan-FP	ZnKa	0.0697
Cu	0.024	%		[0.006]	Quan-FP	CuKa	1.3329
Pb	0.005	%		[0.001]	Quan-FP	PbLb1	0.0226
Br	0.001	%		[0.000]	Quan-FP	BrKa	0.0154

4.3. Laboratory test in Drilling fluids Lab.

Table (4.4) API Standard for mud properties:

API	Minimum	Maximum
Density (Mud Weight)	8.5	9.5
Viscosity	30	46
PH value	7	-
Filter Loss	-	15

1. Abuhasheem pure sample with 76.54% Bentonite:

Table (4-5) pure bentonite properties for Abuhasheem:

weight (g)	MW	ϴ300	ϴ600	PH	F.L(ml)	Time
10	8.3	3	4	7	191	30min
20	8.55	4.5	6	8	191	5hrs
30	8.55	5	6	8	191	10min

Rheological Properties for Abuhasheem:

Table (4-6) pure bentonite Rheological properties for Abuhasheem:

Weight	ϴ300	ϴ600	PV	YP	AV	n	K
10	3	4	1	2	2	0.41	0.23
20	4.5	6	1.5	3	3	0.41	0.34
30	5	6	1	4	3	0.26	0.98

2. Mahatta pure sample with 43.03% Bentonite:

Table (4-7) pure bentonite properties for Mahatta:

weight (g)	MW	Ɵ300	Ɵ600	PH	F.L(ml)	Time
10	8.35	3	4	7	112	30min
20	8.6	4	6	8	112	5hrs
30	8.65	4	6	8	112	10min

Rheological Properties for Mahatta:

Table (4-8) pure bentonite Rheological properties for Mahatta:

Weight	Ɵ300	Ɵ600	PV	YP	AV	N	K
10	3	4	1	2	2	0.41	0.23
20	4	6	2	2	3	0.58	0.11
30	4	6	2	2	3	0.58	0.11

1. Abuhasheem sample mixed with API standard Bentonite

Table (4-9) Abuhasheem sample mixed with API standard Bentonite:

weight (g)	MW	Ɵ300	Ɵ600	PH	F.L(ml)	Mud cake
2.5	8.4	3.5	4.5	8	17	0.05
5	8.45	4	6	9	17	0.1
7.5	8.4	4	6	9	14	0.15
12.5	8.5	7	11	9	11.5	0.17

Rheological Properties for Abuhasheem:

Table (4-10) Abuhasheem sample mixed with API standard Bentonite rheological properties:

Weight	ϴ300	ϴ600	PV	YP	AV	N	K
2.5	3.5	4.5	1	2.5	2.25	0.36	0.37
5	4	6	2	2	3	0.58	0.11
7.5	4	6	2	2	3	0.58	0.11
12.5	7	11	4	3	5.5	0.65	0.12

2. Mahatta sample mixed with API standard Bentonite

Table (4-11) Mahatta sample mixed with API standard Bentonite:

weight (g)	MW	ϴ300	ϴ600	PH	F.L (ml)	Mud cake
2.5	8.4	3	4	8	17	0.05
5	8.5	4	6	9	17	0.1
7.5	8.4	4	8	9	16	0.2
12.5	8.4	6	9	9	14.5	0.22

Rheological Properties for Mahatta mixture:

Table (4-12) Mahatta sample mixed with API standard Bentonite rheological properties

Weight	ϴ300	ϴ600	PV	YP	AV	n	K
2.5	3	4	1	2	2	0.41	0.23
5	t4	6	2	2	3	0.58	0.11
7.5	4	8	4	0	4	0.99	0.01
12.5	6	9	3	3	4.5	0.58	0.16

4.2 Discussion:

Based on results of the tests performed, the following charts were conducted to reflect the behaviors and effect of each properties regardless of concentration.

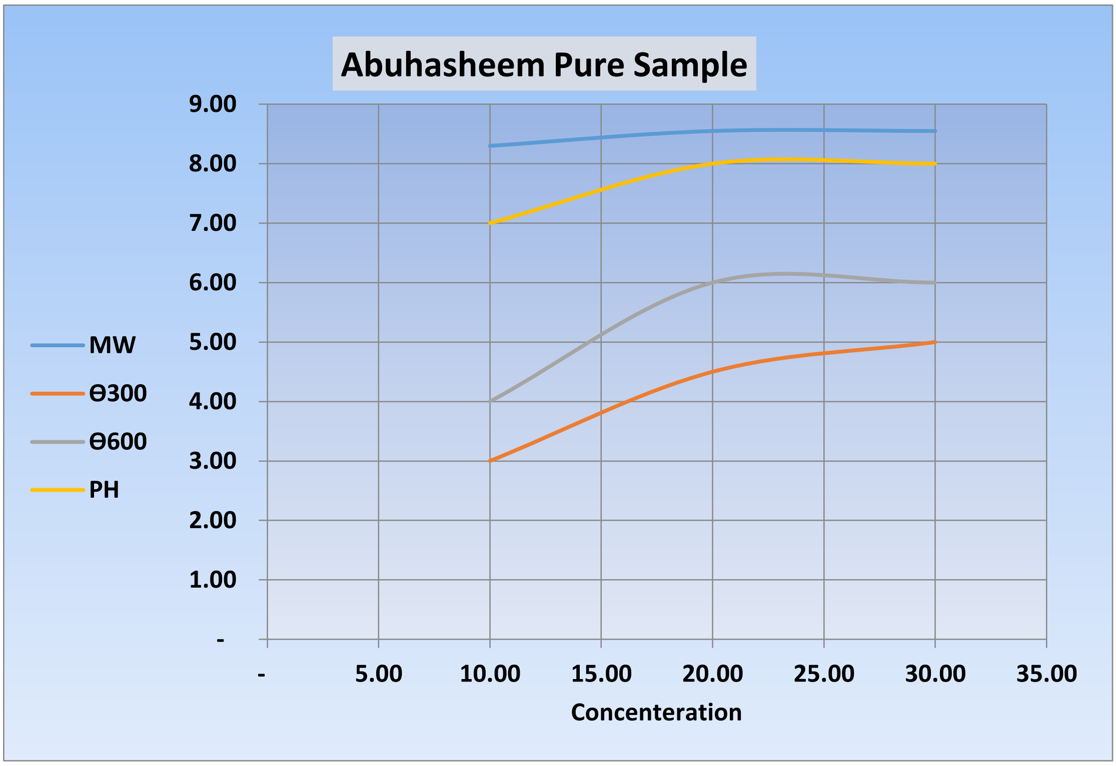


Fig. (4-3) Abuhasheem pure sample

Fig (4-3), Abuhasheem sample when tested observed no considerable increment in viscosity, while MW considerable increasing.

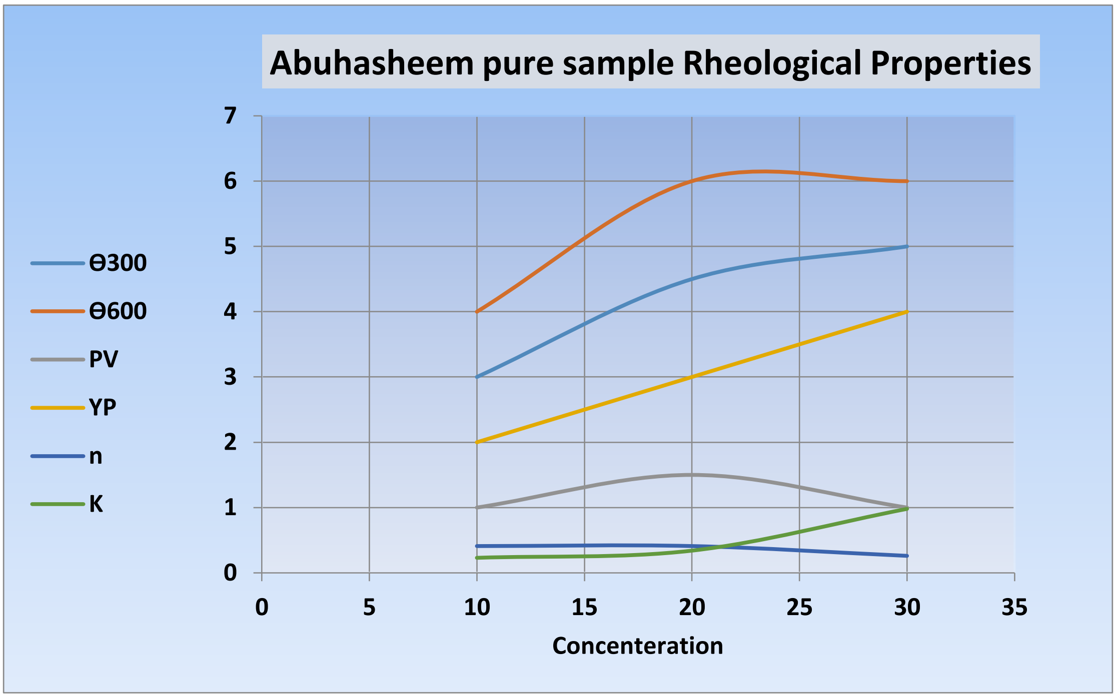


Fig. (4-4) Abuhasheem pure rheological

Fig (4-4), The plastic viscosity (PV) decline, while yield point (YP) increasing.

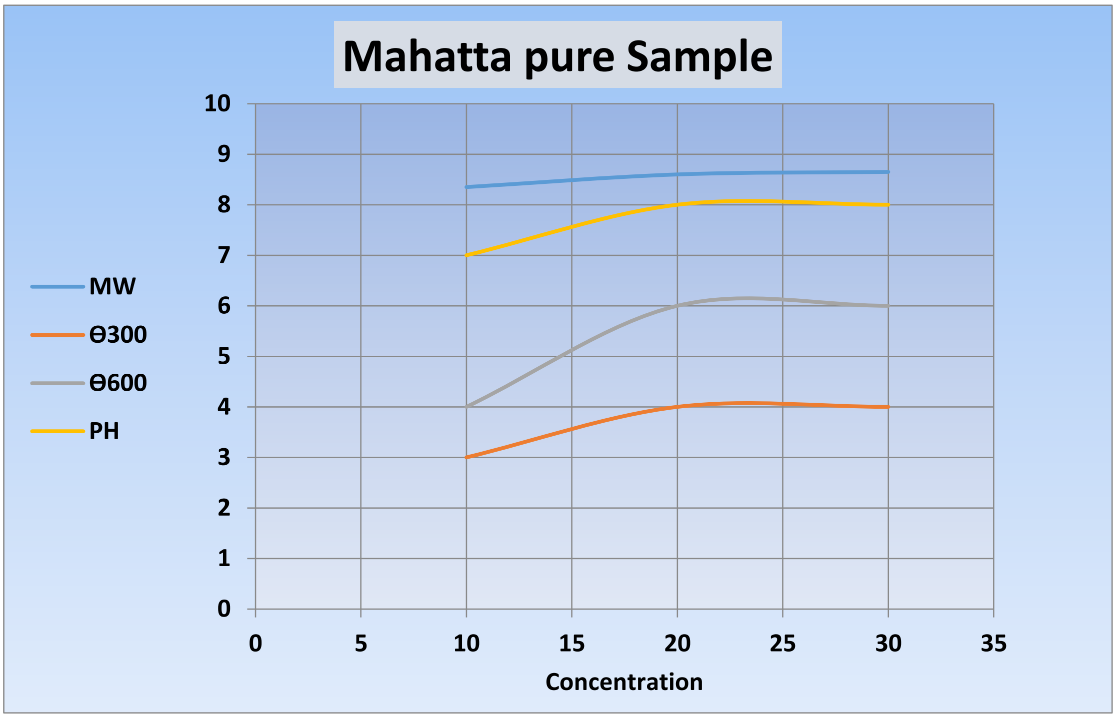


Fig. (4-5) Mahatta pure sample

Fig (4-5), Mahatta sample when tested observed no considerable increment in viscosity, while MW considerable increasing.

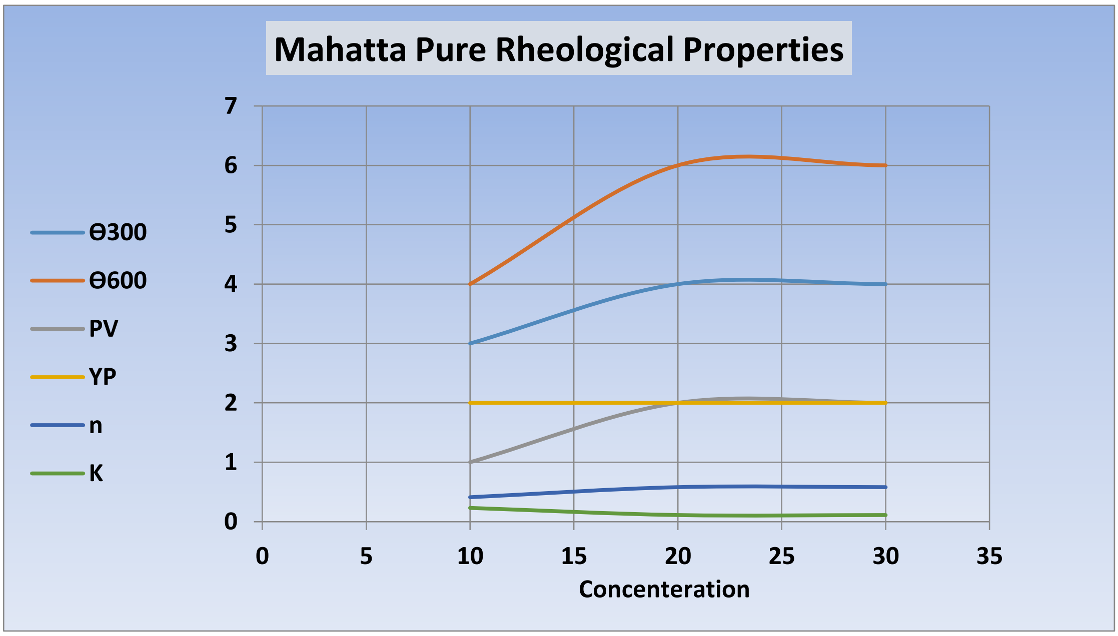


Fig. (4-6) Mahatta pure rheological

Fig (4-6), the plastic viscosity (PV) decline, while yield point (YP) is stable.

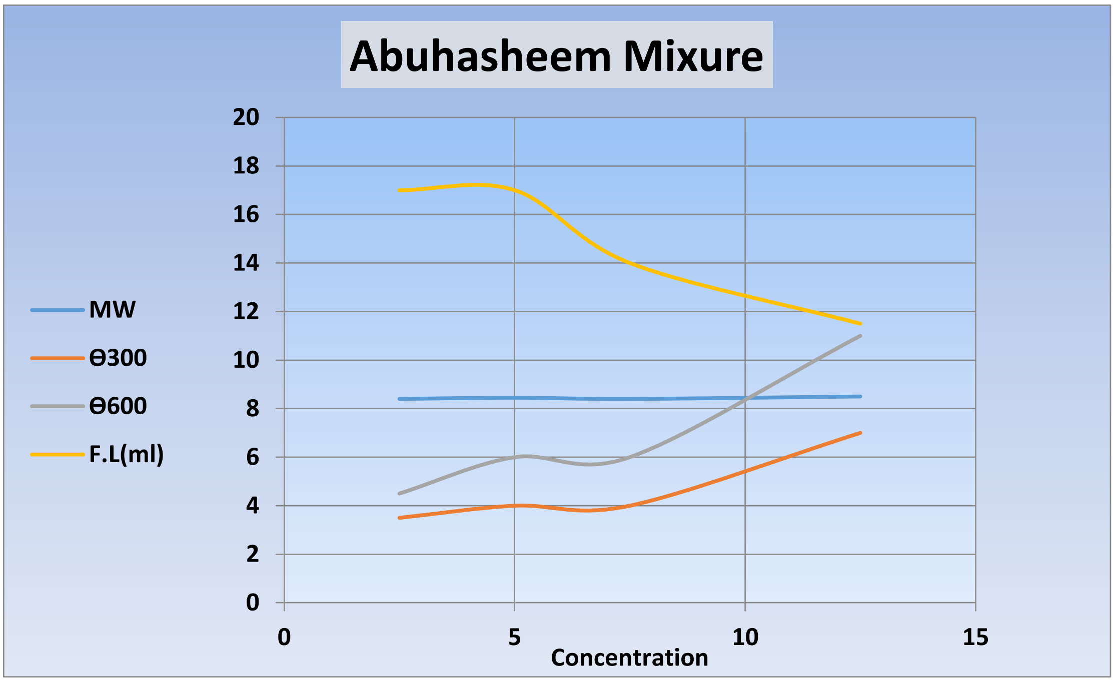


Fig. (4-7) Abuhasheem mixture

Fig (4-7), Abuhasheem mixture when tested observed considerable increment in viscosity, while Filtration decline and, MW stability.

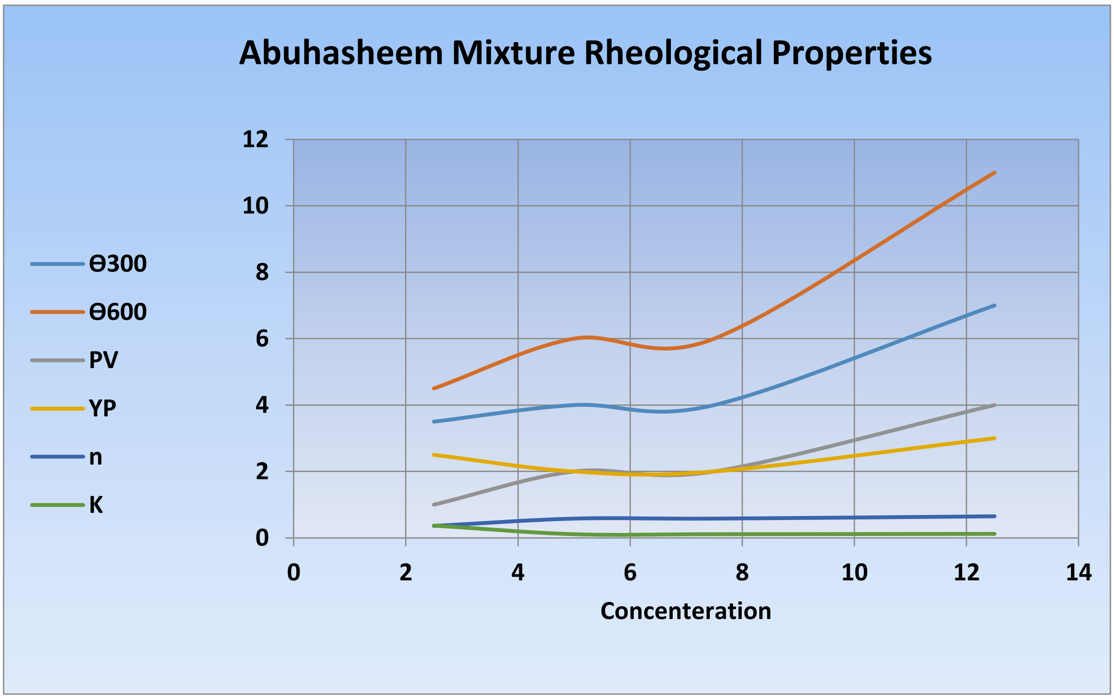


Fig. (4-8) Abuhasheem rheological mixture

Fig (4-8), Abuhasheem mixture when tested observed considerable increment in plastic viscosity (PV) and yield point (YP),

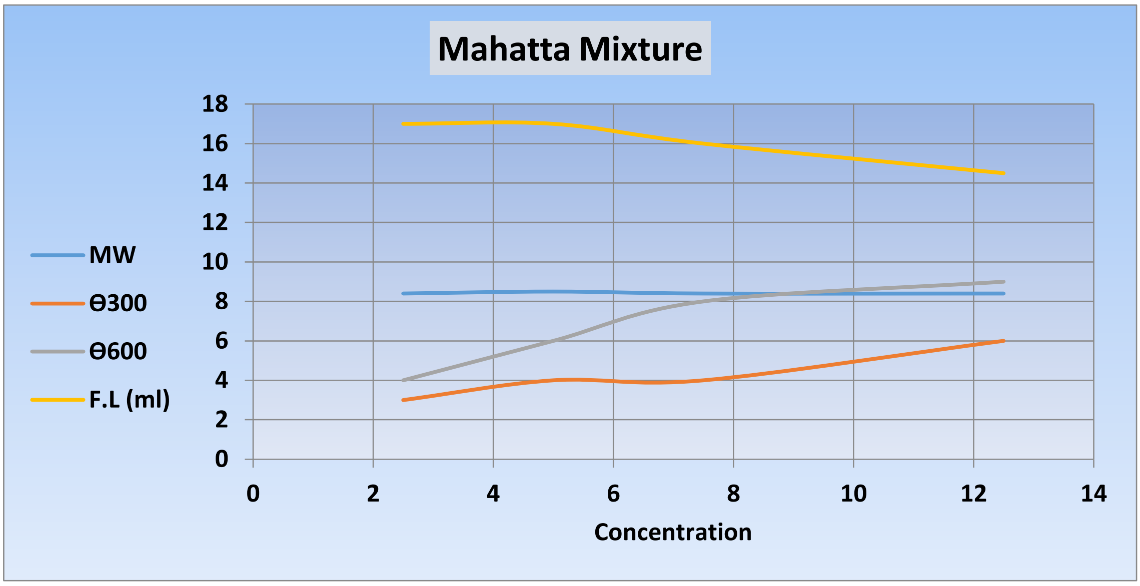


Fig. (4-9) Mahatta mixture

Fig (4-9), Mahatta mixture when tested observed increment in viscosity but not considerable, while Filtration decline also not considerable, MW stability.

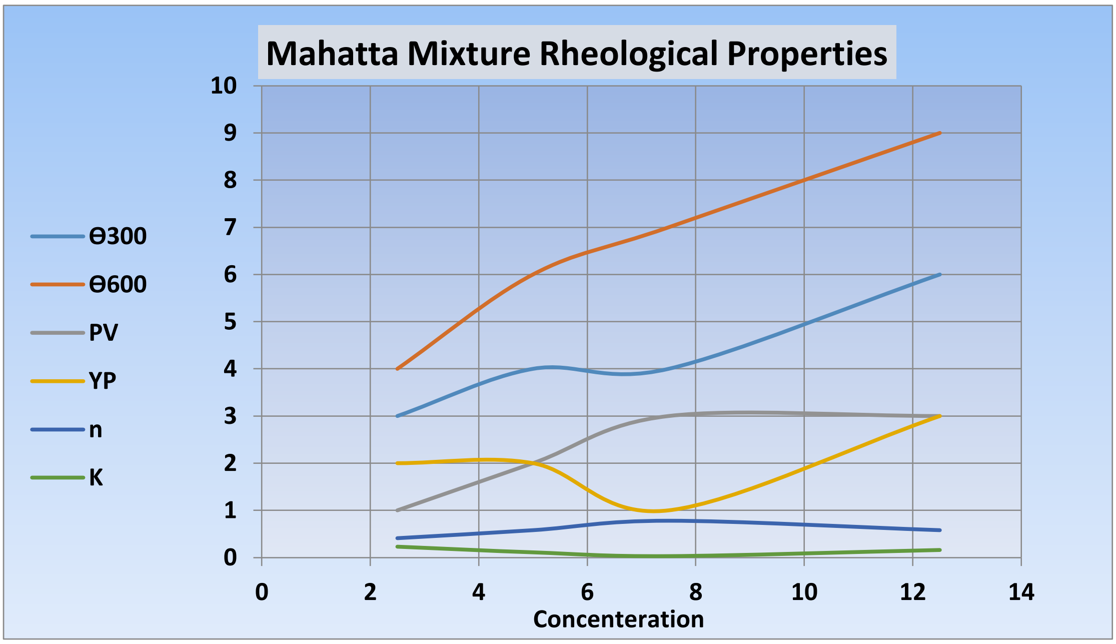


Fig. (4-10) Mahatta mixture Rheological

Fig (4-10), Mahatta mixture when tested observed stability in plastic viscosity (PV) and, increment in yield point (YP).

4.2.1 The Result of Discussion:

Represented in the table below which reflect the effect of viscosity for API standard and actual Abuhasheem mixture data with the concentration.

Table (4.13): Quality of viscosity with concentration:

Weight	Wyoming	Ө300API	Ө600API	Ө300	Ө600
0	0	5	0	0	0
2.5	5	10.5	40	3.5	4.5
5	6.3	13	43.2	4	6
7.5	7	14	45	4	6
10	7.4	15	46.3	5.5	9
12.5	7.5	16.5	47.4	7	11

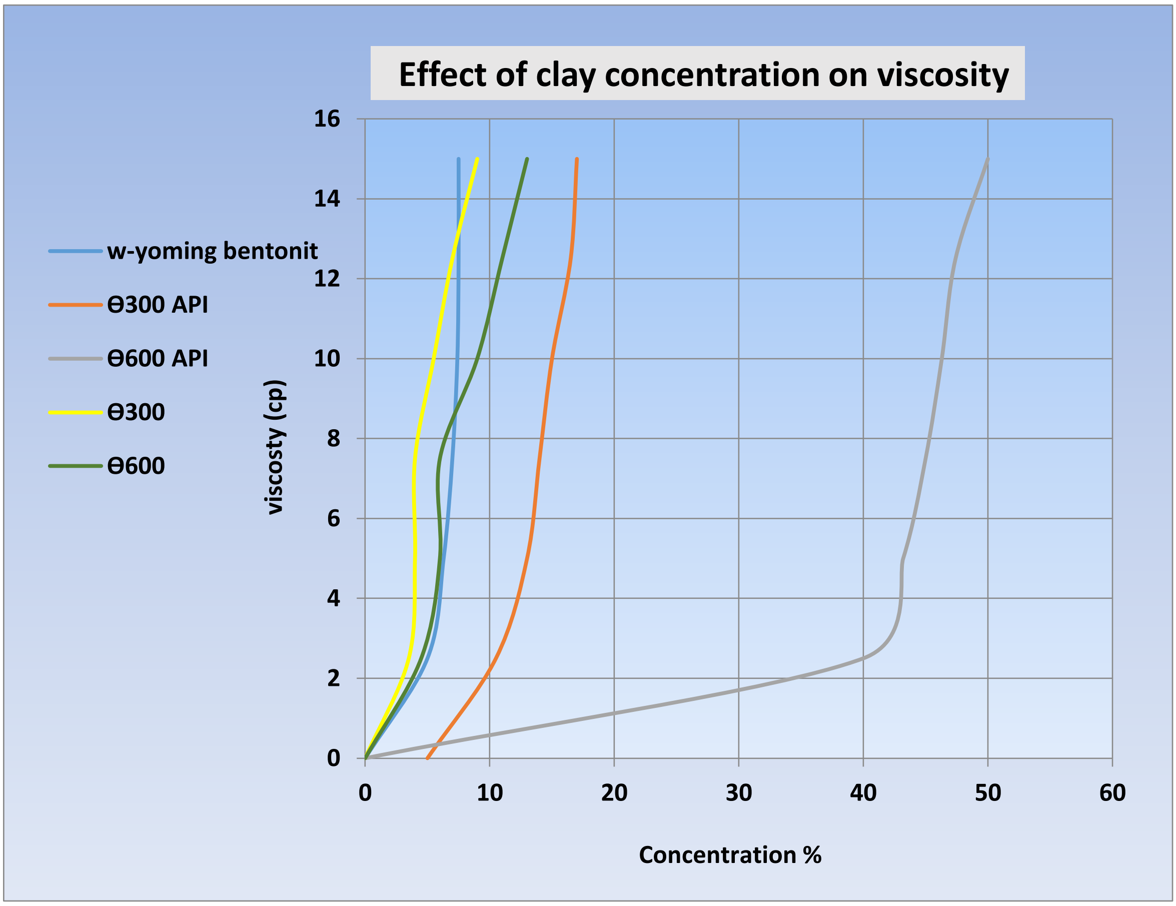


Fig. (4-11) Abuhasheem mixture Quality of viscosity

Chapter 5: Conclusion and Recommendations:

Chapter 5:

Conclusion and Recommendations

5.1 Conclusion:

Based on the results of the tests performed extract the following:

1. The two samples when tested their filtration, the results not compatible with standard API bentonite.

2. The measurement of viscosity for two samples with six speed viscometer not conforms to API standard bentonite but behave manners of hematite.

3. There is a significant increments observed for density (mud weight) measurements of two sample.

4. Abuhasheem sample has considerable percentage of bentonite when tested by XRD analysis.

5. Mahatta sample has lower percentage of bentonite when also tested by XRD analysis.

6. When added API bentonite (50%) to Abuhasheem sample (50%), the result behaves bentonite behaviors with viscosity increment and stability of density, reduction of filtration with increment and PH value range is stable, quality increment with concentration.

7. When added API bentonite to Mahatta sample, the result behaviors changes but not considerable like Abuhasheem.

5.2 Recommendations:

1. Utilization the chemical additives especially for drilling mud for purpose of acquaintance their influence on two samples, the additives such as:

- Flowzan and XCD for viscosity increment.
- Starch for decrease the filtration.
- Soda ash and caustic soda for decrease the hardness and increase the PH value.
- Silicate and KCL for inhibiting

2. Used Abuhasheem sample with API standard bentonite for cost optimization.

Reference:

G.M. Bol, 1991, Bentonite Quality and Quality-Evaluation.

Chisholm, F. 1960 Bentonite in industry: Mines Magazine.

J. W. 1949 Organophilic bentonites, I, Swelling in organic liquids: J. Phys and Colloid Chem 2002 Imaging of Biomedical Data Using a Multiplicative Regularized Contrast Source Inversion Method.

Abu Sabah Elfateih 2013 Study effect of adding a local bentonite in fluids properties Um Ali Mountain.

AMERICIAN PETROLEUM INSTITUTE (API) 2003. Recommended Practice on the Rheology and Hydraulics of Oil-water.

M.I. Abdu, A.M. Alsabagh , M.M. Dardir, 2013 The Nano-bentonite was characterized by X-ray fluorescence analysis (XRF), X-ray powder diffraction (XRD), thermal gravimetric analysis (TGA) and Transmission electron.