Algerian Democratic Republic and Popular

Ministry of Higher Education and Scientific Research

N° serie: ……. /2018

Kasdi Merbah University, Ouargla

Faculty of hydrocarbon, renewable energy, earth and universe science

Drilling and MCP department

Oil and water based mud: characteristic for each section drilled

MASTER OF SCIENCE

Major Subject: Petroleum Drilling Engineering

Submitted By:

Oussama SEFFARI

Ramzi AISSAOUI

Board of member jury:

Mr. Leghrib Youcef	MC	President
Miss. Bouhada Mebarka	MC	Examiner
Mr. Abbas Hadj Abbas	MAA	supervisor

June 2018

Gratitude

First, we thank ALLAH for giving me the power to finish this thesis.

After that we would like to express my thankfulness to our parents who deserve the entire honor of my whole success, and without their support, we would not be here.

With a great pleasure we thank my dear Dr. Mr. Abbas Hadj Abass, who oriented me and helped me with the entire required technical package.

We would like to thank our department professors; Mr.Ilyes Mecibeh, Mr.Lbtahi who have the great favour along of my university career, and also my friends.

Finnaly, special thanks for all those who contributed to finish this work.

Dedication

We dedicate this work to:

Our parents.

Our brothers and sisters.

Our uncles and aunts.

The family SEFFARI.

The family AISSAOUI.

Our friends.

Ramzi and Oussama.

Abbreviation

Mpa, Psi: unity of pressure**.**

BHA: bottom hole assembly.

RPM : round per minute (**tr/min**).

ROP : rate of penetration (**m/h**).

TVD: true vertical depth **(m).**

Mwd: measurement while drilling.

Lwd: logging while drilling.

FEWD: evaluation while drilling.

Ph: Hydrogen ion concentration**.**

OBM: oil based mud**.**

WBM: water based mud**.**

H2s: toxic gaz.

ECD: equivalent circulating density.

HSE: health safety environment.

D: specific gravity of mud.

HMD: Hassi Messaoud.

DOB: disel oil-bentonite.

DOBC: disel oil-bentonite cement squeeze pill.

BOP: blow out preventer.

sg: specific gravity.

HPHT: haut pressure, haut temperature.

O/W: oil/water ratio.

Figure list

Table list

Contents

Contents

Chapter I: Introduction to drilling and drilling fluids

Chapter II: Materials and Methods

Chapter III: Analysis and Discussion

Introduction

A crude oil is composed of a complex mixture of saturated hydrocarbons such as alkanes, aromatic compounds, resins and asphaltenes. The crude oil is the first source of energy in the world.

To exploit hydrocarbons we must pass through several stages, first of all we need to explore a reservoir and after that we move on to the most critical stage which is making sure that the reservoir is exploitable by drilling an exploration wells. These wells will feed us by the most important information about the field, and then we go to production, transportation and marketing

Drilling is complicated operation, depends on three main functions which are: hoisting system, rotating system and circulating system. The drilling fluids require the circulation system to perform numerous functions that help making this possible. The responsibility for performing these functions is held jointly by the mud engineer and those who direct the drilling operation.

The drilling fluid, also called drilling mud, is a system composed of different liquid constituents (water, oil) and / or gaseous (air or natural gas) containing in suspension other mineral and organic additives (clays, polymers, surfactants , cuttings, cement, ...) Drilling fluids are the key element in oil drilling and depending on the excavated soil (dug the manageable land, temperature and humidity ....), we have to change the properties of the few ones of the features of this study, our research will be focusing on these properties and how to change them and the cycle of drilling fluids for well drilling. Also we propose a characteristic study of the water-based and oil-based drilling fluids that are used during the drilling of a oil well according to the phase drilled.

In the first bibliographic chapter, it's very important to start with some definition about drilling (section1) and the history of drilling (section2) , then we talked about drilling rig components (section3) and an introduction about drilling mud with their critical function witch they important to perform numerous functions that help make drill, evaluate and complete a well that will produce oil and/or gas efficiently (section4) including the mud circulation and solid removal and how to select the mud(section4). The waste management is various of regulations that must be followed (section5).

In the second chapter, drilling mud is a very essential element for having a successful drilling operation and the way it should be made for each type of mud (section1). If the mud is not with appropriate characteristic, a lot of problems will appears (section2) then specific test for every mud proprieties.

The third chapter based on the discussion of results about the selection of the mud either OBM or WBM with the appropriate characteristics.

The conclusion that discuss of the drilling excavation and their future technology.

Chapter I

Introduction to drilling and drilling fluid

1. Introduction to drilling:

Drilling is method or way to get the hydrocarbons formation. It's make the connection between the surface and the bottom of the well passing throw many phases [1].

2. Brief history about drilling:

2.1.Drake's well:

In 1859, Drake's well became the first known commercial oil well, planned and drilled solely to search for oil in the United States (Asians and Europeans had been drilling oil wells before). Using the cable-tool method, the well was drilled to a depth of 65 feet and produced 2,000 bbl of oil in its first year. This small project in Titusville, Pennsylvania marked the beginning of the Petroleum area in the United States [2].

2.2. Rotary drilling1863:

In 1863, a French civil engineer named Les chot became the first person to use rotary drilling to drill water well. A rotary drilling rig turns, or rotates, a bit on the bottom, which drills and creates the hole [3]. A series of pipes are added to lower the bit to the bottom. When the bit is at the bottom, the driller starts rotating it using a rotating machine called the rotary table [4]. As the bit's teeth, or cutters, rotate over the formation, they gouge or scrape the rock away. A rotary rig circulates fluid while the bit drills. A powerful pump can move fluid down the pipe to the bit and back through the annulus space to the surface. At the surface, equipment removes the cuttings and the clean fluid is recirculate back down the pipe. Thus, with rotary drilling, drilling does not have to stop in order to bail cuttings [5].

2.3. Spindle top1901:

This method of drilling was introduced in the oil fields of Spindle top, Texas, marking the beginning of the modern petroleum industry. By 1914, 10% of all oil wells were drilled using rotary drilling. Today, except for special applications or the setting of conductor casing, rotary drilling is used almost exclusively. Since then there have been many major advances in the rotary drilling field. New technology is continually being developed to make drilling faster and safer. New developments in the drilling technology have allowed the drilling of horizontal wells wherein the bit can be steered toward the target areas [6].

The development of deep water drilling technology has allowed operators to develop oilfields in very deep water in excess of 3000 meters [7]. Current developments in drilling fluids have increased the rate of penetration and allowed the development of high pressure, high temperature areas that were could not be developed before [8].

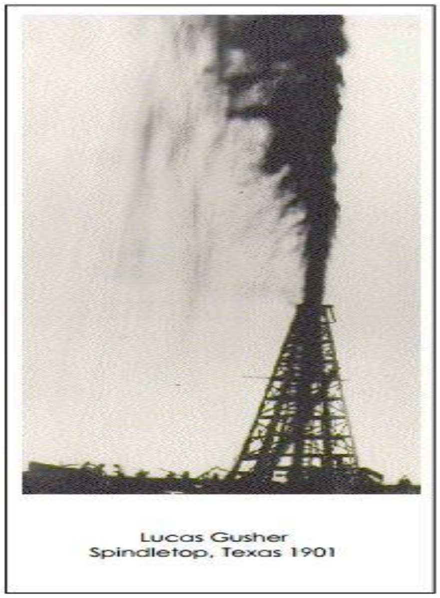

Figure1.1: Spindle top 1901 [1]

3. Rotary drilling rig components:

3.1. Power system:

The power system provides all the energy required for the operation of the rig. A normal drilling rig usually requires from 1,500 to 2,500 kilowatts. The power is delivered by diesel engines, called prime movers. A rig may need from two to four prime movers, depending on its size. The bigger the rig, the deeper it can drill, and the more power it needs. The engines provide power for the draw works, rotary table, and mud pumps. In some cases, the diesel engine powers a generator, which, in turn, powers electric motors. A simple, flexible control system offers flexibility in the placement of equipment. In other cases, the diesel engine provides direct power by the use of gears, chains, belts, and clutches [1].

3.2. Hoisting system:

The most striking feature of a drilling rig is the derrick. In some cases, the derrick can be over50 meters tall. The taller the derrick, the longer the section of pipe that can be handled when going in or pulling out of the hole. This can allow for the adding of two or three joints of pipe at the same time (called doubles and triples), which reduces down-time during the drilling process. The drawworks consists of a large spool of cable and a brake driven by the rig engines. It provides the cable used by the pulleys hung in the derrick. The remainder of the hoisting system consists of blocks and lines that do the actual hoisting: The crown block is a stationary set of pulleys attached to the top of the derrick that gives mechanical advantage in handling large loads. The traveling block is the lower, moving set of pulleys [9].

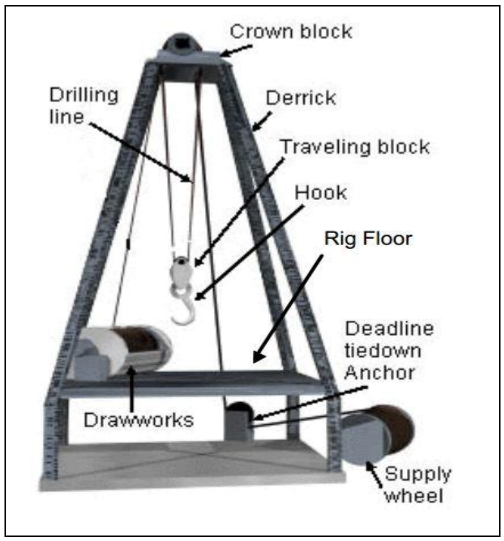

Figure1.2: Hoisting system [1]

3.3. Rotary system:

To make hole, the drill string turns, this causes the bit to cut into the rock and earth. Rotating equipment is two basic types: Either it uses a kelly assembly or a top drive. The kelly assembly includes a swivel, a special length of pipe known as the kelly, the rotary table, and a kelly bushing. Most offshore rigs (and some land rigs) have replaced the conventional swivel, the kelly, and the kelly bushing with a powered swivel called the top drive. In highly deviated (38 degrees or more) and horizontal wells, the torque required to turn the drill string makes rotary-table drilling impractical or impossible. In these situations, a down hole motor is used to rotate the drill bit. When a down hole motor is used, the drill string does not rotate. Instead, the mud is used like hydraulic fluid to supply power to the hydraulic motor, which is placed in the drill string between the bit and the drill collar. Below the swivel is the kelly, a square- or hexagonal-shaped pipe joint that can be turned by the rotary table. This specially shaped joint of pipe allows torque to be applied efficiently to the drilling, without the slippage that might occur with a round joint of pipe. Below the kelly is the drill pipe, and below the drill pipe are the drill collar and the drill bit. Drill collars are heavy, thick-walled joints of pipe inserted between the drill pipe and the drill bit. The heavier weight of the drill collars adds weight to the drill bit, which improves drilling performance [10].

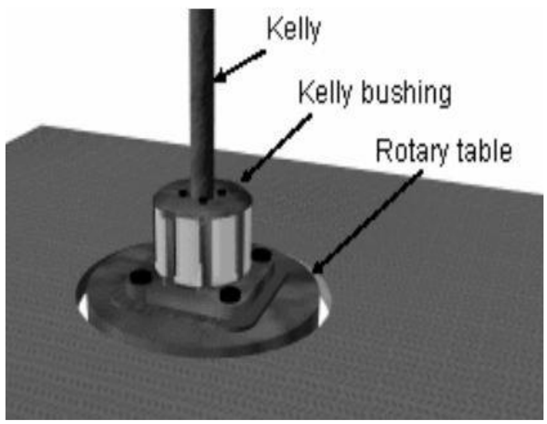

Figure1.3: Rotary system -rotary table- [1]

Figure1.4: Rotary system -top drive- [3]

3.4. Circulating system:

The circulating system is composed of all the components related to the circulation and maintenance of the drilling fluid, which includes the mud pumps, the pipes and hoses required to bring the mud from the pumps to the drill pipe and the annulus, the solids control equipment, and the mud tanks or mud pits. The mud pumps provide the power to circulate the mud into and out of the hole. They are large, positive displacement pumps which are usually rated to pump at above 20 MPa (3000 psi). Mud is kept in pits when it is not down hole. While, historically, these pits were just earthen holes, environmental concerns now require that the pits most often be above-ground containers that protect the environment from contamination. A mud-mixing hopper is attached to the pit, so that materials can be added to the mud to meet changing requirements for density and other mud properties. The solids control equipment removes the drilled solids (cuttings) from the drilling fluid while maintaining the liquids and fine weighting agents as much as possible. Over a period of time the properties of the drilling fluid deteriorate and the fluid needs to be treated or replaced to maintain the desired drilling rate [5].

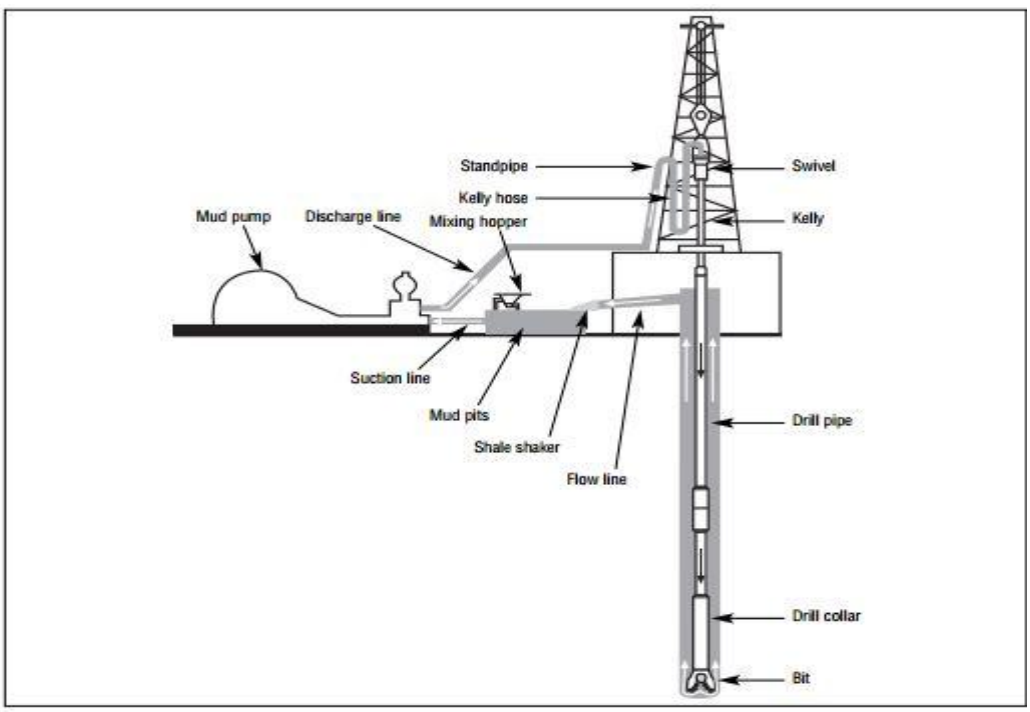

Figure1.5: Circulation system [3]

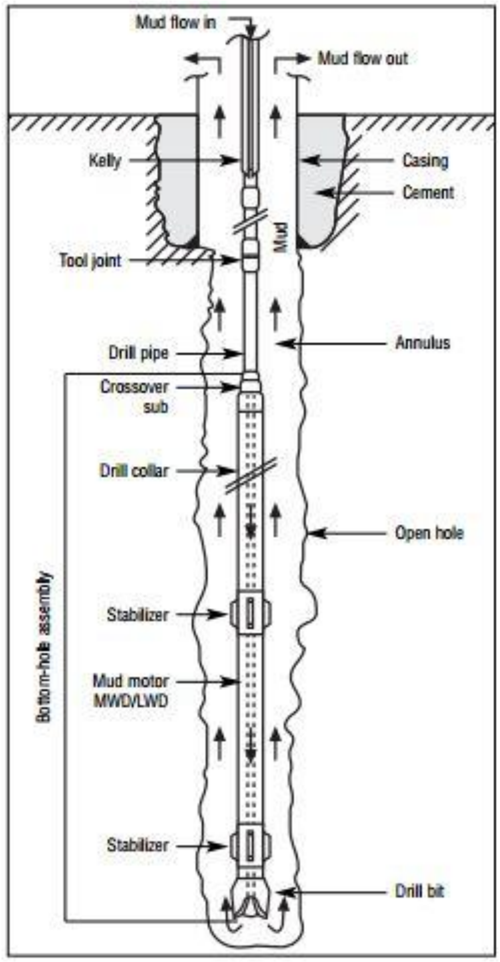

Figure1.6: Circulation system –BHA- [4]

4. Introduction to drilling fluids:

Success in the process of drilling a hole through the earth's crust depends significantly on the performance of the fluid being circulated down the rotating drill pipe, through the bit, and up the annular space between the pipe and the formation or steel casing to the surface. As the search for hydrocarbons reserves intensifies and moves into onshore area, or seeks deeper reserves. So the cost effective performance of the drilling fluid become more critical. The direct cost of the fluid is important but much more important is the total cost of drilling the well, and this can be strongly influenced by the drilling fluid performance. A low cost fluid often does not mean a low cost well. It is for that's reason that the design, formulation and maintenance of drilling fluid are crucial. The term drilling fluid has been chosen in preference to the more widely accepted generic name drilling mud to imply that the properties are design into the system and are not those that occur naturally by mixing water with formation clays. Also drilling fluids may defer dramatically in their composition so that the term mud which implies a simple and water mixture is misleading [11].

4.1. Drilling fluid functions:

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 [12].

4.1.1. Remove cuttings from the well:

Drilling fluid is circulated down the drill string and through the bit, entraining the cuttings and carrying them up the annulus to the surface. Cuttings removal (hole cleaning) is a function of cuttings size, shape and density combined with Rate of Penetration (ROP), drill string rotation, and the viscosity, density and annular velocity of the drilling fluid [12].

4.1.2. Controlling formation pressures:

The pressure exerted by the drilling fluid column while static (not circulating) is called the hydrostatic pressure and is a function of the density (mud weight) and True Vertical Depth (TVD) of the well. If the hydrostatic pressure of the drilling fluid column is equal to or greater than the formation pressure, formation fluids will not flow into the wellbore [13].

4.1.3. Suspend and release cuttings:

Drilling muds must suspend drill cuttings, weight materials and additives under a wide range of conditions, yet allow the cuttings to be removed by the solids-control equipment. Drill cuttings that settle during static conditions can cause bridges and fill, which in turn can cause stuck pipe or lost circulation. Weight material which settles is referred to as sag and causes a wide variation in the density of the well fluid [13].

4.1.4. Seal permeable formation:

Permeability refers to the ability of fluids to flow through porous formations; formations must be permeable for hydrocarbons to be produced. When the mud column pressure is greater than formation pressure, mud filtrate will invade the formation, and a filter cake of mud solids will be deposited on the wall of the wellbore. Drilling fluid systems should be designed to deposit a thin, low-permeability filter cake on the formation to limit the invasion of mud filtrate. This improves wellbore stability and prevents a number of drilling and production problems. Potential problems related to thick filter cake and excessive filtration include “tight” hole conditions, poor log quality, increased torque and drag, stuck pipe, lost circulation, and formation damage [9].

4.1.5. Maintain wellbore stability:

Wellbore stability is a complex balance of mechanical (pressure and stress) and chemical factors. The chemical composition and mud properties must combine to provide a stable wellbore until casing can be run and cemented. Regardless of the chemical composition of the fluid and other factors, the weight of the mud must be within the necessary range to balance the mechanical forces acting on the wellbore (formation pressure, wellbore stresses related to orientation and tectonics). Wellbore instability is most often identified by a sloughing formation, which causes tight hole conditions, bridges and fill on trips. This often makes it necessary to ream back to the original depth. Wellbore stability is greatest when the hole maintains its original size and cylindrical shape. Once the hole is eroded or enlarged in any way, it becomes weaker and more difficult to stabilize. Hole enlargement leads to a host of problems, including low annular velocity, poor hole cleaning, increased solids loading, fill, increased treating costs, poor formation evaluation, higher cementing costs and inadequate cementing [9].

4.1.6. Minimize formation damage:

Protecting the reservoir from damage that could impair production is a big concern. Any reduction in a producing formation’s natural porosity or permeability is considered to be formation damage. This can happen as a result of plugging by mud or drill solids or through chemical (mud) and mechanical (drilling assembly) interactions with the formation [9].

4.1.7. Cool, lubricate, support the bit and drilling assembly.

4.1.8. Transmit hydraulic energy to tools and bit.

Hydraulic energy can be used to maximize ROP by improving cuttings removal at the bit. It also provides power for mud motors to rotate the bit and for Measurement While Drilling (MWD) and Logging While Drilling (LWD) tools. Hydraulics programs are based on sizing the bit nozzles properly to use available mud pump horsepower (pressure or energy) to generate a maximized pressure drop at the bit or to optimize jet impact force on the bottom of the well. Hydraulics programs are limited by the available pump.

4.1.9. Control corrosion:

Drillstring and casing components that are in continual contact with the drilling fluid are susceptible to various forms of corrosion. Dissolved gasses such as oxygen, carbon dioxide and hydrogen sulfide can cause serious corrosion problems, both at the surface and downhole. Generally, low pH aggravates corrosion. Therefore, an important drilling fluid function is to keep corrosion to an acceptable level. In addition to providing corrosion protection for metal surfaces, drilling fluid should not damage rubber or elastomer goods. Where formation fluids and/or other downhole conditions warrant,special metals and elastomers should be used. Corrosion coupons should be used during all drilling operations to monitor corrosion types and rates. Mud aeration, foaming and other trapped-oxygen conditions can cause severe corrosion damage in a short period of time. Chemical inhibitors and scavengers are used when the corrosion threat is significant. Chemical inhibitors must be applied properly. Corrosion coupons should be evaluated to tell whether the correct chemical inhibitor is being used and if the amount is sufficient. This will keep the corrosion rate at an acceptable level. Hydrogen sulfide can cause rapid, catastrophic drillstring failure. It is also deadly to humans after even short periods of exposure and in low concentrations. When drilling in high H2S environments, elevated pH fluids, combined with a sulfide-scavenging chemical like zinc, should be used.

4.1.10. Facilitate cementing and completion:

The drilling fluid must produce a wellbore into which casing can be run and cemented effectively and which does not impede completion operations. Cementing is critical to effective zone isolation and successful well completion. During casing runs, the mud must remain fluid and minimize pressure surges so that fracture-induced lost circulation does not occur. Running casing is much easier in a smooth, in gauge wellbore with no cuttings, cavings or bridges. The mud should have a thin, slick filter cake. To cement casing properly, the mud must be completely displaced by the spacers, flushes and cement. Effective mud displacement requires that the hole should be near gauge and the mud must have low viscosity and low, non-progressive gel strengths. Completion operations such as perforating and gravel packing also require a near gauge wellbore and may be affected by mud characteristics.

4.2. Mud circulation and solid removal:

A logical place to begin the discussion of a mud circulation system is at the mud pumps. These pumps and the engines that power them, represent the “heart” of the mud system just as the circulating mud is the lifeblood of the drilling operation. Mud pumps are positive-displacement piston pumps, some of which produce up to 5,000 psi. They are powered by diesel engines or electric motors. To produce the required pressure and flow rate for a specific set of drilling conditions, the correct piston and liner sizes must be selected for the pumps and the right nozzle sizes must be specified for the bit. This is called hydraulics optimization, and it’s a key factor in efficient drilling. After exiting the mud pump at high pressure, the drilling fluid travels up the standpipe, a long, vertical pipe attached to the derrick leg, then through the kelly hose (rotary hose), through the swivel and down the kelly. The mud then travels down the drillstring to the bit. A bit will usually have two or more nozzles (jets) which accelerate the mud to a high velocity. This jet of mud scours the bottom of the hole to keep the bit cutters clean and keep a fresh rock surface for the bit to attack. From the hole bottom, the mud moves upward in the annular space between the drillstring and the wellbore, carrying the cuttings generated by the bit [14].

The mud and its load of cuttings flow out of the “bell nipple” and through a large-diameter, sloping pipe (flow line) onto one or more vibrating wire-mesh screens mounted on the shale shaker. The idea is that the mud falls through the screens and most of the cuttings (which are bigger than the screen's mesh) are separated from the circulating system. When the mud falls through the screen, it drops into a settling pit. These pits are large, rectangular, metal tanks with pipe or troughs connecting them. The settling pit is not stirred so that any remaining larger solids can settle out of the mud. From the settling pit, the mud moves into stirred mud pits downstream where gas, sand and silt are removed. After that, the mud moves to the suction pit where the pumps pull it out for recirculation downhole. The suction pit is also used for the addition of treating chemicals and mud conditioning additives. A mud hopper with venturi is used in this pit for adding dry additives such as clays and weighting agents [15].

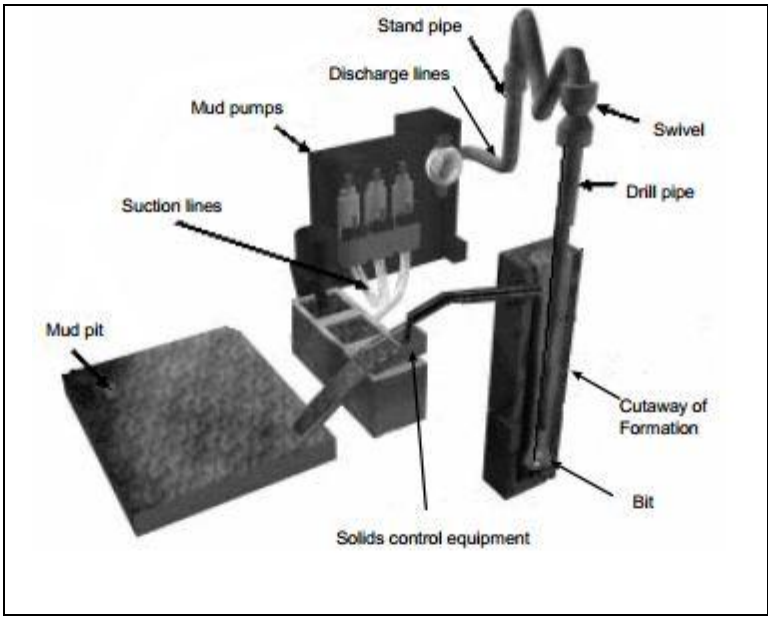

Figure1.7: Mud circulation and solid removal [5]

4.3. Mud selection:

Wells are drilled in a series of sections of progressively increasing depth and decreasing diameter. It is common for two, three or even more different types of fluid to be used in the process. For example, the large diameter 'top hole' sections commonly drilled to around 1500 feet below sea bed will use a low cost bentonite or guar gum mud. Further down, a polymer or oil based fluid may be chosen. Occasionally different fluids may be used for drilling into the reservoir or during well completion operations (before the well is put on production). Drilling fluid selection depends primarily on geological factors such as the type of rocks to be drilled and anticipated downhole temperatures and pressures. One of the key parameters is the level of inhibition. For example in the North Sea area, most wells penetrate a thick layer of Tertiary and Cretaceous claystones which cause many problems if not drilled with an inhibitive system such as oil based drilling fluid. Generally, inhibitive fluids (e.g. KCl/Polyacrylamide or polyglycerol containing fluids) require less dilution because the cuttings do not hydrate and disperse as readily as in uninhibitive muds (e.g. dispersed bentonite). Most countries require information on toxicity, biodegradability, and bioaccumulation potential of drilling fluids. Water-based muds, in particular are regarded as being more environmentally acceptable than oil based mud. In general WBM gives a less stable wellbore and produces larger gauge holes than oil based muds. There is also more dispersion of solids into the mud (hence higher dilution requirements and more waste). The use of oil based mud may be acceptable on cost or technical grounds. Oil based muds have better properties in terms of viscosity, fluid loss control, thermal stability, and lubricity [16].

4.4. The following information should be collected and used when selecting drilling mud for a particular well:

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

➢Offset well data from similar wells in the area to help establish successful mud systems problematic formations, potential hazards, estimated drilling time.

➢Geological plot of the prognoses lithology.

➢Casing design program and casing seat depths.

➢Basic mud properties required for each open hole section before it is cased off.

4.5. Guidelines for the mud engineers:

➢The mud laboratory cabin should be fully equipped with all standard equipments and reagents required to run all tests as per the norms API (RP 13B1 & B2 & RP13J).

➢A sufficient and appropriate stock of Lost Circulation Material at different grades must be available on rig site; an L.C.M. pill should be prepared before start drilling into the formations with risk of losses.

➢Report flow line temperature regularly with each mud check. All rheology measurements are being performed at 120/150° F.

➢ At the beginning of the hole section, or if the fluid has not been circulated for over 24 hours, care should be taken regarding Shale Shaker screen size and flow rate. Initially it will take one to two circulations for the mud to fully shear and warm up. The objective is to prevent losses due to screen blinding.

➢Prior to pulling out of the hole, ensure balanced mud properties and if necessary sweep hole with 30 - 40 bbl High-Vis pill. Spot a High-Vis pill on bottom prior to running casing. Ensure the high viscosity pills are made from active mud to ensure uniform mud properties.

➢Always ensure that annular velocities are kept below critical in the open hole to reduce erosion and ECD's. Mud Hydraulics should be reported daily and when any influencing parameters change.

➢All supervisory personnel on site should be informed of any planned dilution/mixing and of the subsequent estimated changes in pit levels; Driller and Mud logger specifically.

➢ Any major treatments to the mud should be pilot tested first. This will ensure cost effective treatment. Due to the inert nature of the system, results from the pilot test normally correspond closely with the results obtained in the active system. It must be remembered that for some treatments, 2 to 3 circulations may be needed before the effects are seen.

➢High penetration rates and flow rates can cause blocking of the flow line and header box causing whole mud losses from both. To avoid this, we recommend the installation of at least one mud gun in the base of the header tank, drawing mud from the final solids control pit. The mud gun(s) should be run during every connection and will successfully flush out this tank.

➢High viscosity pills or weighted low viscosity pills should be pumped to monitor hole cleaning. The volume of cuttings should be observed when the pill returns to surface. If increased cuttings are observed, more pills should be pumped or the YP increased. A fully documented sweep report should be completed each time a pill is pumped. Furthermore, high viscosity pills should be pumped any time a hole cleaning problem is suspected and a circulation made before any trip.

➢ The mud engineer will report the situation of the operations twice a day, that is every morning and afternoon.

➢The mud engineer will notify the technical supervisor about any changes in the mud characteristics or in the daily operations at the well site, as well as any kind of anomalies produced at any given moment.

➢ The mud engineer will perform a complete mud check each time new mud arrives at location, and the results will be posted on the daily mud report as well.

➢ Mud engineers will perform a minimum of 4 mud checks per day, and results will be mentioned on the daily mud report.

➢ All instructions from mud engineer to Derrick man should be written (showing time and date) and given to Derrick man, tool pusher and company man on location.

➢ Complete and detailed hand over reports will be given between mud engineers at the end of each shift.

5. Health, safety and environmental:

Awareness of the environment among the public, regulatory agencies, customers and service companies has made environmental concerns a key factor in drilling operations. Environmental issues are broad-based and complex, influencing all aspects of drilling fluid system design and use. Health, Safety and Environmental (HS&E) regulations overlap to some degree, but they consider the issues from different perspectives. Health and safety issues deal primarily with worker protection, while environmental issues deal with any impact to the environment and/or the health of the community exposed to the effects of drilling operations. Preventing pollution and minimizing environmental impact in a cost-effective way are the foremost tasks confronting the industry today. M-I and SWACOT are committed to developing products and waste management technology that enhance drilling and production while protecting the environment and the well-being of the people who use our products [17].

5.1. Waste management options for drilling fluids and cuttings:

5.1.1. Onshore option:

The primary considerations involved in disposal of muds and associated wastes used onshore are heavy metals, salt and hydrocarbon content. Most U.S. states regulate the permitting, processing and disposal of reserve pit contents with regard to these three parameters. When trying to determine the best method for disposal of such mud constituents, the operator must consider the economics, the disposal operation, the environmental impact of the final product and any residue. Several disposal methods are approved for reserve pit cleanup. As long as the environmental impact is controlled, the operator has the option to choose the most cost-effective method for handling the waste. In the future, however, some common disposal methods found today probably will be restricted, and the economics therefore may not play as strong a role as they do now. The total cost of the disposal method selected includes the operating cost, transportation, energy use, maintenance, labor and disposal of any residue formed. Also, the operator must consider potential future liability. When dealing with the operational issues, important factors include safety, reliability and processing rate. Finally, the operator must consider the environmental impact. If governmental regulations are satisfied for the waste generated, then the operator must test the residue formed during the process and determine the proper method for its disposal. Questions to be answered include: Does the unit create any air, water or solid waste emissions? Is the process an integral part of the operation or a separate unit? If the unit is separate, then the processed waste may be covered under separate regulations and may not be exempted for the oil and gas industry [17].

5.1.2. Environmental regulations:

Environmental regulations have an impact on drilling fluid products and fluid systems, either directly through restrictions or indirectly through controls such as economics. Products are tested during both development and manufacturing stages before being released to the marketplace. Drilling fluid systems are complex and are regulated as a whole rather than by their parts. Chemical constituents are tested individually to determine environmental and health impacts. Regulations dealing with products and fluid systems are divided into offshore and onshore schemes.

Note: Environmental regulations vary by country and by locale. No attempt is made here to detail these regulations, which can change rapidly. The discussion is intended only to acquaint the reader with the nature of regulations [18].

Chapter II

Materials and Methods

1. Introduction:

Drilling mud is a very essential element for having a successful drilling operation, the proper mixing and treatment of the mud is the key word for drilling wells and passing to the next phases safely, quickly and keeping the environment clean [19].

for each phase the mud has a different character with the others such as density, viscosity, electric stability, ratio oil /water, gel strength and ph…

So what are the agents that control each character of the drilling mud? And on what basis do we determine its value?

2. Well presentation:

2.1. Well location: the well OMJZ 333 is located as showing in the table:

Table2.1: well location [20]

Itineraries d' acces	Goudron	Piste A	Piste B	Piste C	Total
24 February → Ember. TOUGOURT	**20.6**				**20.6**
Ember.TOUGOURT→ Forage OMJZ.332				**0.3**	**0.3**
TOTAL(Km)	**20.6**			**0.3**	**20.9**

2.2. Synoptic map for the well OMJZ 333:

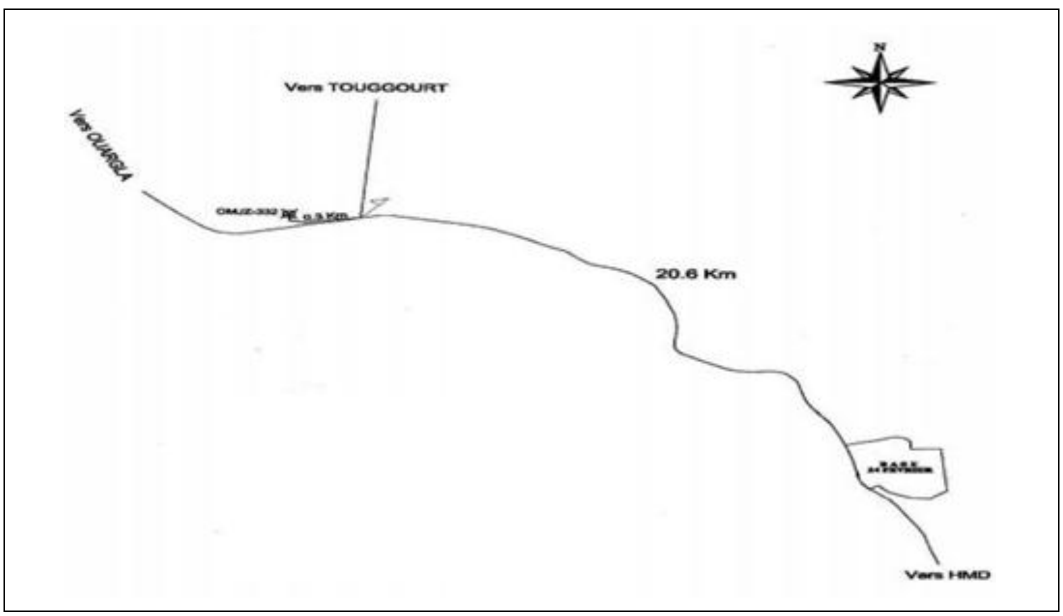

Figure2.1: synoptic map for the well OMJZ333 [20]

2.3. Well summary:

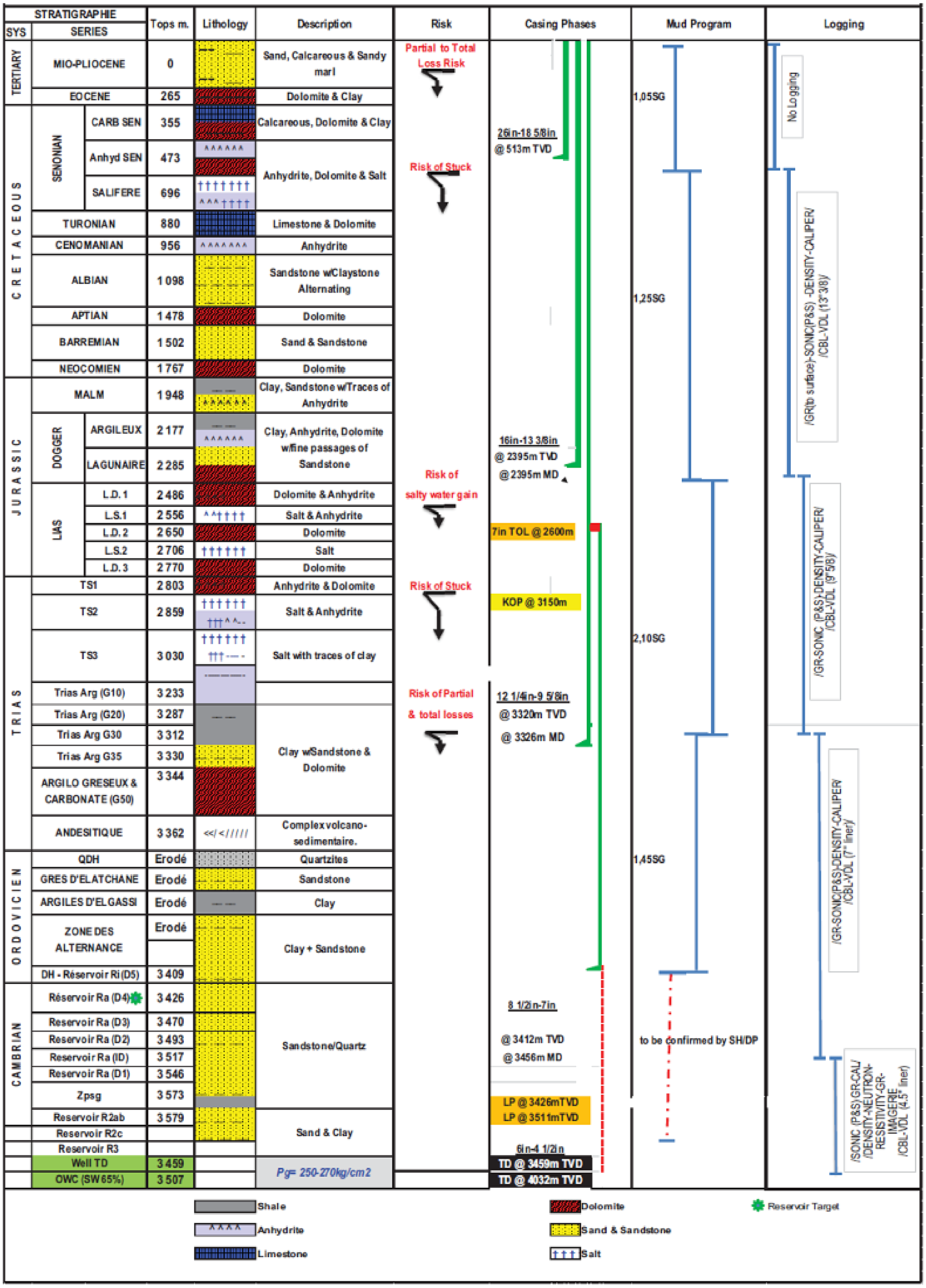

Figure 2.2: Well summary OMJZ 333 [20]

3. Preparatin of drilling mud (mixing procedures):

3.1. Water based mud (section 26"):

The BENTONITE should be pre hydrated in advance for at least 6 hours in order to allow the clays to swell and provide good rheology.

➢Add Soda Ash to reduce the hardness less than 0,4g/l.

➢Add the BENTONITE and agitate with maximum shear for at least 6 hours.

➢Add Caustic Soda to increase the pH if necessary [21].

3.2. General Considerations for WBM:

➢A sufficient stock of drill water and BENTONITE must be available on rig site.

➢ The mix water should tested before any mud mixing in order to evaluate the pretreatment to carry out to get less than 1000ppm chlorides and less than 400ppm hardness.

➢The BENTONITE should be pre hydrated in advance for at least 6 hours in order to allow the clays to swell and provide good rheology.

➢Dilution with water merely results in large volumes to be treated and no solids are actually removed from the system. It is preferable therefore to adopt the technique of whole mud dilution. This involves dumping old, solids laden mud at the sand traps and replacing this with a similar volume of clean fluid at the suction. Whilst this may at first appear to be an expensive process it does in practice prove economical as chemicals are not used to try and overcome problems in the mud system due to high solids content.

➢Should signs of bacterial degradation occur, the system should be treated with 1.0 l/m3 bactericide and the pH increased to 10,5.

➢A mud detergent and a lubricant should be used to avoid bit balling problems and to provide lubrication in order to prevent stuck pipe [22].

3.3. Oil based mud (section 16"):

The Invert Emulsion AVOIL System is easy to build and maintain. After calculating the quantity of the different products to add, the Oil/Water ratio and density required proceed as follows:

➢In an isolated, clean pit, mix the Sodium Chloride Brine to a concentration of 26% by weight.

➢To the mixing pit add the required quantity of Diesel, then, add the AVABENTOIL SA.
➢Add successively AVOILPE, AVOIL SE, & Lime, and mix on max shear for 20 minutes.
➢Slowly add the required volume of Brine to the oil mixture and leave to mix on maximum shear for 20 minutes.
➢Add the AVOIL FRHT.
➢Finally add the amount of weighting agent for the required density [21].

3.4. Oil based mud (section 12" ¼):

The Invert Emulsion AVOIL System is easy to build and maintain. After calculating the quantity of the different products to add, the Oil/Water ratio and density required proceed as follows:

➢ In an isolated, clean pit, mix the Sodium Chloride Brine to a concentration of 26% by weight.
➢To the mixing pit add the required quantity of Diesel, and then add the AVABENTOIL SA.
➢Add successively AVOIL PE, AVOIL SE, & Lime, and mix on max shear for 20 minutes.
➢ Slowly add the required volume of Brine to the oil mixture and leave to mix on maximum shear for 20 minutes.
➢ Add the AVOIL FRHT, finally add the amount of weighting agent for the required density [21].

3.5. Oil based mud (section 8" 1/2):

The Invert Emulsion AVOIL System is easy to build and maintain. After calculating the quantity of the different products to add, the Oil/Water ratio and density required proceed as follows:

➢ In an isolated, clean pit, mix the Sodium Chloride Brine to a concentration of 26% by weight.
➢ To the mixing pit add the required quantity of Diesel, and then add the AVABENTOIL SA.
➢ Add successively AVOIL PE, AVOIL SE, & Lime, and mix on max shear for 20 minutes.
➢ Slowly add the required volume of Brine to the oil mixture and leave to mix on maximum shear for 20 minutes.
➢ Finally add the AVOIL FRHT, AVOIL WA, and then the amount of weighting agent for the required density [21].

3.6. Oil based mud (section 6"):

The Invert Emulsion AVOIL System is easy to build and maintain. After calculating the quantity of the different products to add, the Oil/Water ratio and density required proceed as follows:

- In an isolated, clean pit, mix the Sodium Chloride Brine to a concentration of 26% by weight.
- To the mixing pit add the required quantity of Diesel, and then add the AVABENTOIL SA.
- Add successively AVOIL PE, AVOIL SE, & Lime, and mix on max shear for 15 minutes.
- Slowly add the required volume of Brine to the oil mixture and leave to mix on maximum shear for 10 minutes.
- Finally add the AVOIL FC or AVOIL FR/ND, AVOIL WA, and then the amount of weighting agent for the required density if necessary [21].

3.7. General Considerations for OBM:

- It is important that a good emulsion be maintained at all times. If the emulsion is poor, then the HTHP filtrate is likely to contain emulsion or brine, and water wetting of solids may occur. This may increase the viscosity and cause blinding of the shaker screens and settlement of weighting agent.
- A daily treatment of primary and secondary emulsifiers in the range of 1.50 to 3.0 kg/m3 is usually sufficient to maintain a good emulsion. Additions of wetting agent will be required if adding large quantities of weighting agent.
- If traces of water occur in the filtrate, treatment with emulsifiers and/or fluid loss additives is required. For fluid losses below 10 ml, additions of emulsifiers are recommended.
- Any major treatments to the mud should be pilot tested first. This will ensure cost effective treatment. Due to the inert nature of the system, results from the pilot test normally correspond closely with the results obtained in the active system. It must be remembered that for some treatments, particularly Organophylic clays, 2 to 3 circulations may be needed before the effects are seen [22].

4. Problems caused by bad mud:

- ➢**Kick.**
- ➢**Stuck pipe.**

In drilling operations, the drillpipe is considered stuck when it cannot be raised, lowered, or rotated. Stuck pipe can be caused by several different mechanisms. Typical stuck pipe situations are:

➢Differential-pressure effects.

➢ Packing off.

➢Undergauge hole.

➢ Keyseating [23].

4.1. Differential sticking:

Most incidents of stuck pipe are caused by differential pressure effects. Excessive differential pressures across lower-pressure permeable zones can cause the drillstring to push into the wellbore wall where it becomes stuck.

Differential sticking may be identified by the following characteristics:

➢ Pipe sticks after remaining motionless for a period of time.

➢ Pipe cannot be rotated or moved when circulation is maintained [24].

Note: Differential pressure effect.

The difference in pressure between the hydrostatic head pressure and the formation pore pressure forces the drillpipe into the wallcake and sticks the pipe. To avoid or minimize the risk of differential sticking, follow these guidelines:

➢Drill with the lowest practical mud weight.

➢Maintain a low filtration rate.

➢Keep low-gravity solids to a minimum.

➢Never allow the drillpipe to remain motionless for any period of time.

➢Ream any undergauge section.

➢Add appropriate bridging agents.

➢Change to an oil/synthetic-based mud [24].

4.2. Lost circulation:

Lost circulation or loss of returns describes the complete or partial loss of fluid to the formation as a result of excessive hydrostatic and annular pressure drop. Lost circulation is characterized by a reduction in the rate of mud returns from the well compared to the rate at which it is pumped downhole (flow out < flow in). This leads to a decrease in pit volumes. Loss of circulation may be detected by a sensor monitoring return flow rate or by pit volume indicators. Depending on the severity of the rate of mud loss, drilling operations may be significantly impaired. If the annulus of the well will not remain full even when circulation of the fluid has ceased, the hydrostatic pressure will reduce until the differential pressure between the mud column and the loss zone is zero. This may induce formation fluids from other zones, previously controlled by the mud hydrostatic pressure, to flow into the wellbore resulting in a kick, blowout, or underground blowout. It may also cause previously stable formations to collapse into the wellbore. Lost circulation can occur in the following formations: [25]

Table2.2: lost circulation and their type depend on the type of the formation [25]

Type of formation	**Type of loss**
Cavernous/vugular	Complete or partial
Highly permeable or fractured	Complete or partial
Permeable	Seepage loss

4.2.1. Formations in which circulation may be lost Cavernous/ vugular formations:

The circulation lost in a cavernous/vugular formation is the most severe type of loss that can occur because the mud loss is immediate and complete. Cavernous formations are associated with limestone reefs, dolomite beds, or chalks. The loss occurs in actual caverns or crevices in the formation [26].

4.2.1.1. Indication:

This type of lost circulation is usually easy to diagnose because the bit can drop several inches or even feet when it breaks through the top of the cavern [26].

4.2.1.2. Treatment:

The following methods are recommended for combating lost circulation due to cavernous/ vugular formations:

➢Add 40 to 60 lb/bbl (114-171 kg/m3) coarse-grade products such as: (BARACARB, BARO-SEAL, BAROFIBRE Coarse, JELFLAKE, MICATEX, STEELSEAL, WALL-NUT).
➢Spot a high filtration pill such as Diaseal® M or ZEOGEL. C Spot a gunk diesel-oil-bentonite (DOB) or dieseloil- bentonite cement (DOBC) squeeze pill. Synthetic based fluids may be substituted as a carrier. C Drill blind (if possible) until the loss zone can be cased off [26].

4.2.2. Fractured formations:

Permeable or fractured formations can result in partial or complete loss of circulation. Formation fractures can be natural or caused by excessive drilling fluid pressure on a structurally weak formation. Once a fracture has been induced, the fracture will widen and take more mud at a lower pressure. To avoid inducing formation fractures: Maintain the minimum equivalent-circulating density (ECD) and mud weight. Avoid pressure surges [27].

4.2.2.1. Indication:

Lost circulation of this type is indicated by a complete or partial loss of returns and a decrease in pit volume [27].

4.2.2.2. Treatment:

If a induced fracture is suspected, the hole can be allowed to heal by pulling into the casing and waiting 6 to 12 hours. After the waiting period, stage back to bottom and check for full returns. If full returns have not been established, treat the losses as if they were cavernous/vugular losses [27].

4.2.3. Permeable formations:

Permeable and porous formations include: Loose, non-compacted gravel beds, Shell beds, Reef deposits and Depleted reservoirs. These types of formations cause seepage loss to complete loss of returns [28].

4.2.3.1. Indication:

Seepage into permeable formations is indicated by partial to full loss of returns and decrease in pit volume [28].

4.2.3.2. Treatment:

The following methods are recommended for combating this type of loss:
➢Reduce mud weight as much as possible.

➢Treat the system with a combination of fine- to medium-grade lost-circulation products such as: (BARACARB, BAROFIBRE, BARO-SEAL, HY-SEAL, MICATEX, STEELSEAL) [28].

4.2.4. Corrective procedures and formulations Gunk squeeze:

When you are faced with a lost circulation problem and you are using an oil/synthetic mud, mix the gunk squeeze with water and GELTONE instead of oil/synthetic and bentonite. Formulations for water based and oil/synthetic based gunk slurries are listed in Tables 1 and 2.

Table2.3: Gunk formulation for water-based muds [29]

Type	**Additions per barrel of diesel**	
Bentonite, lb (kg)	**Cement, lb (kg)**	
Diesel-oil/synthetic bentonite	400 (181)	0 (0)
Diesel-oil/synthetic bentonite cement	200 (91)	200 (91)

This example uses a dieseloil/synthetic bentonite or diesel-oil/synthetic bentonite cement mixture. If PETROFREE / PETROFREE LE/XP-07 is being used, substitute appropriate base fluid for diesel oil [29].

Table2.4: Water-GELTONE gunk squeeze formulation [29]

Material	**Mud weight**		
(1.26 sg) 10.5 lb/gal	**(1.56 sg) 13 lb/gal**	**(1.92 sg) 16 lb/gal**	
Water, bbl (m3)	0.660	0.628	0.582
Q-BROXIN, lb (kg)	3.5 (10)	3.5 (10)	3.5 (10)
Caustic soda, lb (kg)	1.5 (4)	1.5 (4)	1.5 (4)
*GELTONE, lb (kg)	220 (627)	150 (428)	100 (285)
BAROID, lb (kg)	—	175 (499)	370 (1,055)

This formulation is for oil/synthetic-based muds. Use the GELTONE recommended for the area.

To mix a gunk squeeze, follow these steps:

➢Drain and clean the mixing tank thoroughly.

➢Prepare a gunk slurry (diesel oil/synthetic bentonite cement, diesel-oil bentonite, or water-GELTONE; see Table 2.

➢Pump the following in this order: Spacer to cover approx. 500' of drillstring, Squeeze to cover approx. 2 times open hole volume, Spacer to cover approx. 500' of drillstring

Note: The spacer fluid should have the same base fluid as the squeeze.

➢Displace the squeeze to the bit.

➢Close blowout preventers (BOPs).

➢Pump down the drill pipe and annulus in equal volumes until the squeeze and spacer are displaced from the drill pipe.

➢ Maintain equal pressure on drillpipe and casing.

4.2.5. Cross linkable:

4.2.5.1. LCM pill:

N-SQUEEZE may be used as an essentially nondamaging crosslinkable LCM pill. This pill is designed to control whole fluid losses or seepage losses. It may be both pumped as sweep or cross linked and spotted across a loss zone. If required, the pill may be weighted with calcium carbonate or barite. Cleanup can accomplished by flow back, acidizing, or biodegradation[26].

Note: The highest degree of formation damage protection is provided when N-SQUEEZE is used alone or with calcium carbonate as a weighting agent. The N-SQUEEZE pill may be mixed in freshwater, KCl or NaCl brines. It reaches its highest yield in water with a lower salinity value.

4.2.6. Locating the loss zone:

The best source of information for determining loss zones is your knowledge of the formations and the characteristics of a given region.

4.2.7. More specific methods for locating the loss zone include:

➢Measurement-while-drilling (MWD) .

➢ Sperry Sun's Formation, Evaluation While Drilling (FEWD).

➢ Radioactive tracers.

➢Temperature surveys.

➢Hot-wire surveys.

5. Mud rheology test –Mud weigh, Mud viscosity, Ph- :

5.1. Mud weight or density test:

➢**Theory:**

The density of the drilling fluid must be controlled to provide adequate hydrostatic head to prevent influx of formation fluids, but not so high as to cause loss of circulation or adversely affect the drilling rate and damaging the formation. Normal pressure gradient by water is equal to (0.433 psi/ft) and equal to433 psi/1000 ft [30].

5.1.1. Test equipment:

The Baroid Mud Balance as shown below is used to determine density of the drilling fluid. The instrument consists of a constant volume cup with a lever arm and rider calibrated to read directly the density of the fluid in ppg (water 8.33), pcf (water 62.4), specific gravity (water = 1.0) and pressure gradient in (62.4/144)=0.433psi/1000 ft. (water 433 psi/1000 ft) [30].

Figure 2.3: Typical Mud Balance [30]

5.1.2. Calibration:

➢Remove the lid from the cup, and completely fill the cup with water.
➢Replace the lid and wipe dry.
➢Replace the balance arm on the base with knife-edge resting on the fulcrum.
➢The level vial should be centered when the rider is set on 8.33. If not, add to or remove shot from the well in the end of the bream.

5.1.3. Test procedure:

➢Remove the lid from the cup, and completely fill the cup with the mud to be tested.
➢Replace the lid and rotate until firmly seated, making sure some mud is expelled through the hole in the cup.
➢Wash or wipe the mud from the outside of the cup.
➢Place the balance arm on the base, with the knife-edge resting on the fulcrum.
➢Move the rider until the graduated arm is level, as indicated by the level vial on the beam.
➢At the left-hand edge of the rider, read the density on either side of the lever in all desired units without disturbing the rider.
➢Note down mud temperature corresponding to density.

5.2. Mud viscosity using Marsh Funnel:

➢ **Theory:**

The viscosity of a fluid is defined as its resistance to flow. The desired viscosity for a particular drilling operation is influenced by several factors, including mud density, hole size, temperature, pumping rate, drilling rate, pressure system and requirements, and hold problems. The indicated viscosity as obtained by any instrument is valid only for that rate of shear and will differ to some degree when measured at a different rate of shear. For field measurements the marsh funnel has become the standard instrument. For laboratory, the Fann V-G meter, a direct indicating rotational multi-speed instrument has become the standard, allowing measurements of plastic viscosity, yield point, gel strength to be made. The Stormer viscometer is still, however, used to some extent for single point (apparent) viscosity and 0-10 min. gel [30].

5.2.1. Test equipment:

The Marsh Funnel is a device that is common to every drilling rig. Details of the Marsh Funnel and receiving cup are shown in Figure2.3. The viscosity is reported in seconds allowed to flow out of the funnel.
API specifications call for 1500 ml and one quart (946) ml out. Gallon=3.7 Lt for API water at 70 F $\pm$ 0.5^{o}F = 26 $\pm$ 0.5 sec. The Marsh Funnel measures the apparent viscosity.

5.2.2. Calibration:

Fill the funnel to the bottom of the screen (1500 ml) with water at 70 F (plus or minus 0.5 F) time of outflow of the quart (946 ml) should be 26 seconds plus or minus 1/2 second.

Figure 2.4: Marsh Funnel and One-liter Cup [30]

5.2.3. Test procedure:

➢With the funnel in an upright position, cover the orifice with a finger and pour the freshly collected mud sample through the screen into a clean, dry funnel until the fluid level reaches the bottom of the screen (1500 ml). ➢Immediately remove the finger from the outlet and measure the time required for the mud to fill the receiving vessel to the 1-quart (946 ml) level.

➢Report the result to the nearest second as Marsh Funnel Viscosity at the temperature of the measurement in degrees Fahrenheit or Centigrade.

5.3. Hydrogen ion concentration (pH):

➢**Theory:**

The acidity and the alkalinity of the drilling fluid can be measured by the concentration of the (H^+) ion in the fluid. As for instance, if H^+ is large (1 x 10^{-1}), then the (OH^-) hydroxyl concentration is very low (1 x 10^{-13}), the solution is strongly acidic. If the (OH^-) concentration is (1 x 10^{-1}) very high then (H^+) concentration is very low then the solution is strongly alkaline. The pH of a solution is the logarithm of the reciprocal of the (H^+) concentration in grams moles per liter, expresses as:

$$\text{PH} = \text{Log}\left\{\frac{1}{H^+}\right\} = -\log\left[H^+\right]$$

➢**Example:**

If the solution is neutral then H^+ and OH^- concentrations are the same equal to 1 x 10^{-7}.

$$\text{PH} = \log\left(\frac{1}{1x10^{-7}}\right) = -\log\left[1x10^{-7}\right] = -(-7) = 7.00$$

$$= -\log 10^{-7}$$

Therefore, if the pH of a mixture drops from 7.0 to 6.0, the number of (H^+) increase ten times. The pH of a mud seldom is below 7 and in most cases fall between 8 and 12.5 depending upon the type of mud. The pH is important because the pH affects the solubility of the organic thinners and the dispersion of clays presents in the mud.

5.3.1. Methods of measuring pH in the laboratory:

5.3.1.1. The pH Paper: The pH paper strips have dyes absorbed into the paper display certain colors in certain pH ranges. It is useful, inexpensive method to determine pH in fresh water muds. The main disadvantage is that high concentrations of salts (10,000 ppm chloride) will alter the color change and cause inaccuracy.

5.3.1.2. The pH Meter: The pH meter is an electric device utilizing glass electrodes to measure a potential difference and indicate directly by dial reading the pH of the sample. The pH meter is the most accurate method of measuring pH.

Figure 2.5: Hydrion pH Dispensers [30]

Figure 2.6: pH Meter [30]

6. Mud rheology test -Viscosity, Gel Strength and Yield Point-:

Rheology refers to the deformation and flow behavior of all forms of matter. Certain rheological measurements made on fluids, such as viscosity, gel strength, etc. help determine how this fluid will flow under a variety of different conditions. This information is important in the design of circulating systems required to accomplish certain desired objectives in drilling operations [30].

6.1. Viscosity using Variable Speed Rheometer:

➢Theory:

Viscosity is defined as the resistance of a fluid to flow and is measured as the ratio of the shearing stress to the rate of shearing strain. Two types of fluid characterizations are:

➢ Newtonian (true fluids) where the ratio of shear stress to shear rate or viscosity is constant, e.g. water, light oils, etc.

➢ Non-Newtonian (plastic fluids) where the viscosity is not constant, e.g. drilling muds, colloids, etc.

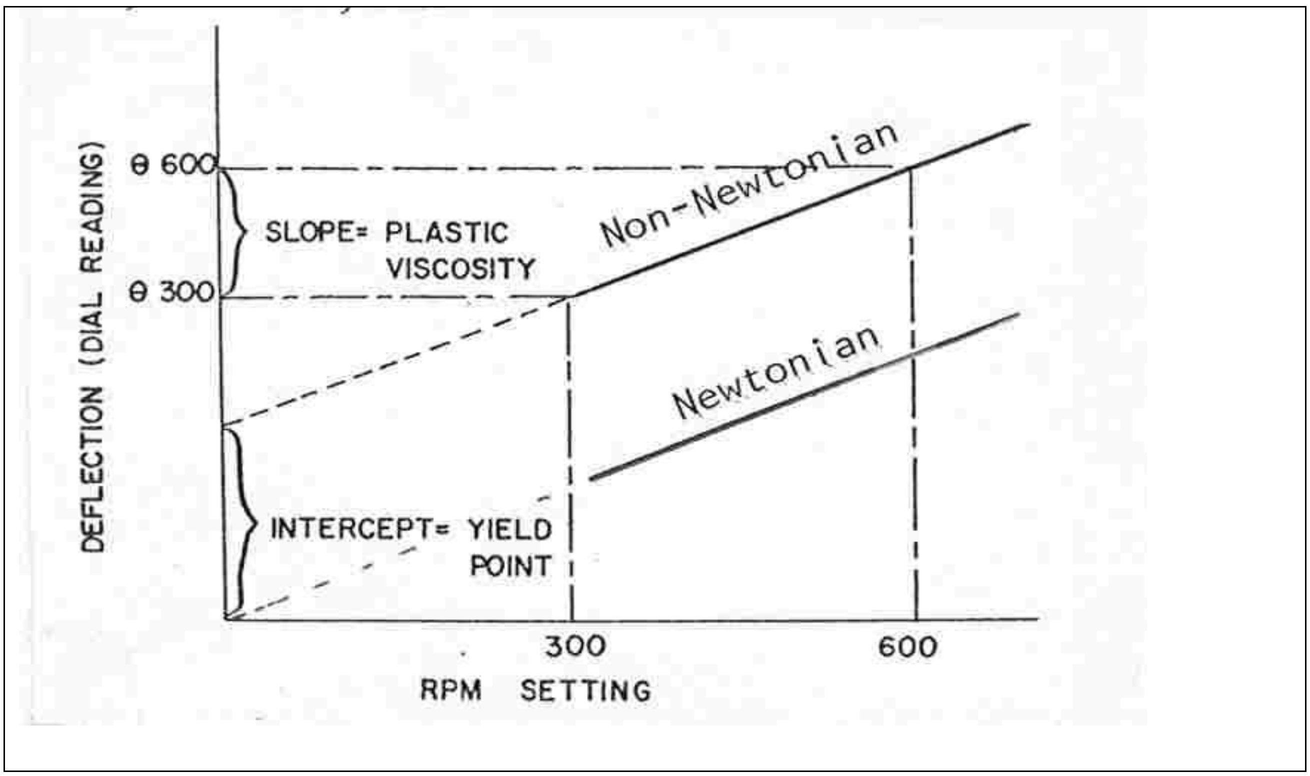

Figure 2.7: Flow Curves of Newtonian and non-Newtonian Fluids [30]

6.1.1. Test equipment:

The Baroid (Model 286) Rheometer is a coaxial cylindrical rotational viscometer, used to determine single or multi-point viscosities. It has fixed speeds of 3 (GEL), 100, 200, 300 and 600 RPM that are switch selectable with the RPM knob.

Figure 2.8: Variable Speed Rheometer [30]

Additionally, the same switch set to the VAR position enables speed selection of between 3 and 625 RPM, by manual adjustment of the variable knob.

6.1.2. Viscosity measurement procedures:

- Place a recently agitated sample in the cup, tilt back the upper housing of the rheometer, locate the cup under the sleeve (the pins on the bottom of the cup fit into the holes in the base plate), and lower the upper housing to its normal position.
- Turn the knurled knob between the rear support posts to raise or lower the rotor sleeve until it is immersed in the sample to the scribed line.
- Stir the sample for about 5 seconds at 600 RPM, then select the RPM desired for the best.
- Wait for the dial reading to stabilize (the time depends on the sample's characteristics).
- Record the dial reading and RPM.

Note: Rheological calculations:

- Plastic viscosity (in centipoise-up):

Plastic Viscosity = μ_p = 600 RPM reading - 300 RPM Reading

➢Apparent Viscosity (in centipoise-cp):

$$\textbf{Apparent Viscosity} = \mu_a = \frac{\textbf{600 RPM Reading}}{}$$

➢Yield Point (in lb/100 ft^2):

Yield Point = Y P = 300 RPM Reading - Plastic Viscosity

6.2. Gel strength:

➢Theory:

The Baroid Rheometer is also used to determine the Gel strength, in lb/100 sq. ft., of a mud. The Gel strength is a function of the inter-particle forces. An initial 10-second gel and a 10-minute gel strength measurement give an indication of the amount of gellation that will occur after circulation ceased and the mud remains static. The more the mud gels during shutdown periods, the more pump pressure will be required to initiate circulation again.

Most drilling muds are either colloids or emulsions which behave as plastic or non-Newtonian fluids. The flow characteristics of these differ from those of Newtonian fluids (i.e. water, light oils, etc.) in that their viscosity is not constant but varied with the rate of shear, as shown in Figure 2.2. Therefore, the viscosity of plastic fluid will depend on the rate of shear at which the measurements were taken.

6.2.1. Gel strength measurement procedures:

➢Stir a sample at 600 RPM for about 15 seconds.
➢Turn the RPM knob to the STOP position.
➢Wait the desired rest time (normally 10 seconds or 10 minutes).
➢Switch the RPM knob to the GEL position.
➢Record the maximum deflection of the dial before the Gel breaks, as the Gel strength in lb/100 ft^2 (lb/100 ft^2 x 5.077 = Gel strength in dynes/cm^2).

6.3. Yield point:

➢**Theory:**

This is the measure of the electro-chemical or attractive forces in the mud under flow (dynamic) conditions. These forces depend on (1) surface properties of the mud solids, (2) volume concentrations of the solids and (3) electrical environment of the solids. The yield point of the mud reflects its ability to carry drilled cuttings out of the hole [30].

➢**Measurement: YP = 300 RPM - Plastic Viscosity**

6.3.1. Experimental procedure:

➢Obtain a recently agitated mud sample from each of mud tanks (1) and (2).
➢Using the Baroid Rheometer, obtain dial readings at 3, 300 and 600 RPM.
➢By means of the rheological calculations procedure, determine the Apparent and Plastic.
➢Viscosities, Yield Point and initial 10 sec. and final 10-minute Gel Strength parameters.

6.4. Filtration:

➢**Theory:**

The loss of liquid from a mud due to filtration is controlled by the filter cake formed of the solid constituents in the drilling fluid. The test in the laboratory consists of measuring the volume of liquid forced through the mud cake into the formation drilled in a 30 minute period under given pressure and temperature using a standard size cell.

It has been found in early work that the volume of fluid lost is roughly proportional to the square root of the time for filtration. The two commonly determined filtration rates are the low pressure,low-temperature and the high-pressure high-temperature [30].

6.4.1. Test equipment:

The low pressure test is made using standard cell under the API condition of 100 $\pm$ 5 psi for 30 minutes at room temperature. Another special cell, will be used to measure filtration rate at elevated temperatures and pressure.Filter press used for filtration tests consists of four independent filter cells mounted on a common frame. Each cell has its own valve such that any or all the cells could be operational at the same time. Toggle valve on the top of each cell could be operated independently for the supply of air for each individual cell. Special high pressure and high temperature filtration tests are run in the laboratory simulating formation temperature and formation back- pressure.

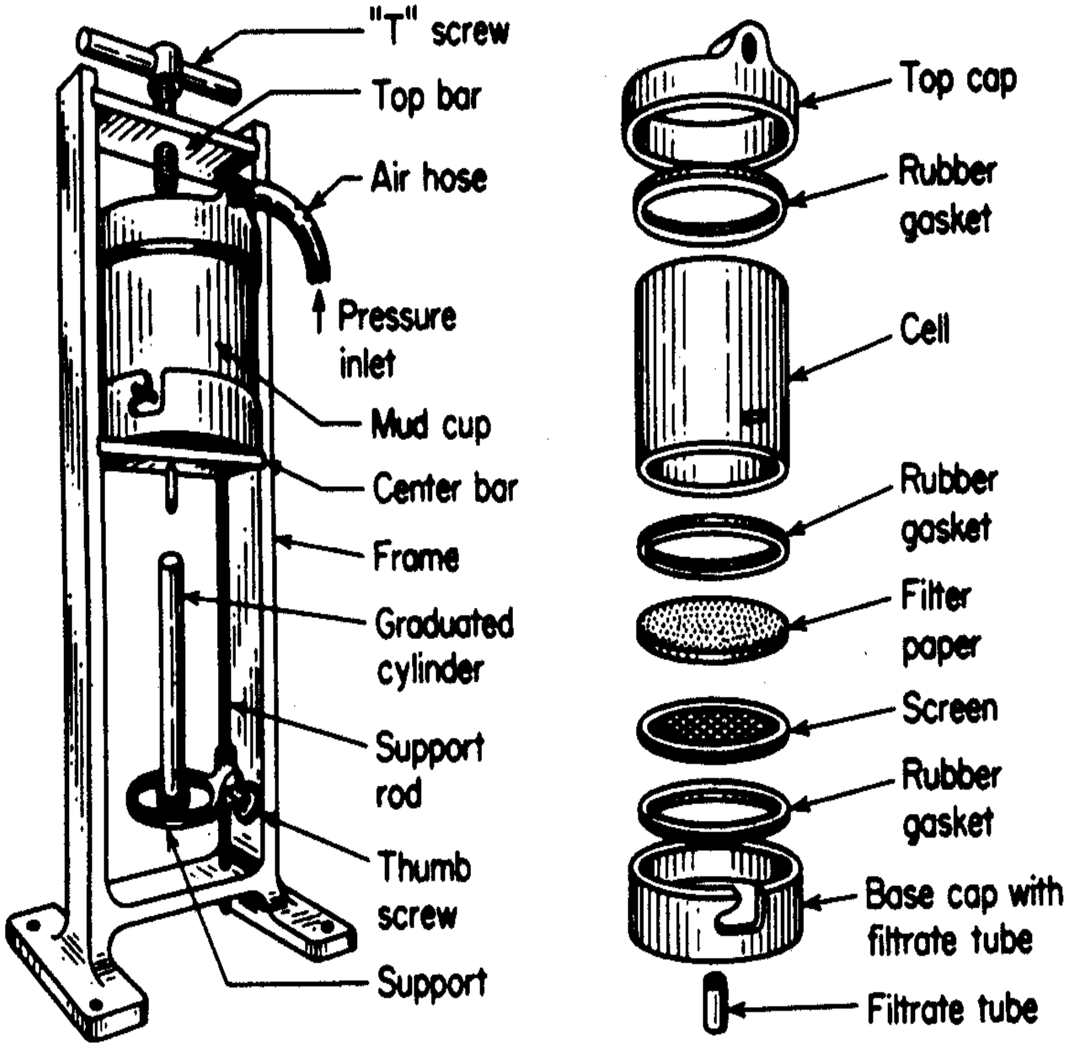

Figure 2.8: Standard API Filter Press [34]

Figure 2.9: High Temperature High Pressure Filter Press [30]

6.4.2. Test procedure for filtration at 100PSI and room temperature:

➢Detach the mud cell from filter press frame.

➢Remove bottom of filter cell, place right size filter paper in the bottom of the cell.

➢Introduce mud to be tested into cup assembly, putting filter paper and screen on top of mud tighten screw clamp.

➢With the air pressure valve closed, clamp the mud cup assembly to the frame while holding the filtrate outlet end finger tight.

➢Place a graduated cylinder underneath to collect filtrate.

➢Open air pressure valve and start timing at the same time.

➢Report cc of filtrate collected for specified intervals up to 30 minutes.

6.5. Wall builds:

6.5.1. Measurement procedure for mud cake thickness. (32 nd of an inch or cm):

It should be reported in thirty-second of an inch in whole number. VERNIER caliper could be used to measure the thickness, however, while measuring care should be taken not to press VERNIER jaw on mud cake to penetrate through. Results on mud cake thickness should be reported in whole number [30].

Chapitre III

Results and Discussions

1. Introduction:

At **75%** of Rig up the mud engineer should be present on the rig site. He starts testing and reception of all low pressure mud installation according to SONATRACH procedures. Verify the condition and tightness of mud pits and pits gates. Monitor and test the operation of all solids control equipments. Check and inventory all screens available on rig site and order what is missing. Supervise the assembly and testing of the centrifuges before spud date. Check the number and condition of the screens available on rig site to be used for receiving of oil based mud. Flush the water line. Fill all tanks with water and mixed the spud mud.

2. Mud program during the drilling of the well OMJZ 32:

2.1. Section 26" PROGRAM:

2.1.1. Interval from 00m to 513 m:

This section will be drilled with a simple Fresh water-Gel Mud which is economical and has sufficient gels to provide good suspension of cuttings when the pumps are off and good carrying capacity for hole cleaning. The objective of this section is to case off major loss zones prior to displacement to OBM.

2.1.2. Discussion:

Higher overall viscosities will be required to unable low pump rate while drilling out the shoe and the surface formations. As drilling progresses, the pump rate will be increase progressively to ensure maximum hole cleaning. The incorporation of High Viscosity Sweeps into the circulating system is recommended in order to boost the hole cleaning rheology and filtrate control while maintaining the lowest practical mud weight.

The use of AVAGUM or CMC HVT is an option and in addition to provide high viscosity, its secondary benefit is to reduce the filtrate of the mud and form a thin mud cake. But it is used except in the case of poor performance of the BENTONITE. To prevent bit balling, it is recommended to treat the system with 0.2 to 0.4% of Ecol Lube and 0.3 to 0.5% of Avadeter. Ensuring that the pH of the mud is high (10.0 to 12), will aid the dispersion of sticky clays. Prior pulling out to run in the 18"5/8 casing, the active system should be treated at 3 m before the casing point with 4 to 5 kgs/m3 of CMC LVT to reduce the filtrate below 20 ml to ensure wellbore stability and minimize hole fill while tripping and running casing. To provide good hole cleaning before run casing, Once this section is drilled to total depth pump Hi-Vis pill sweep and circulate until have a clean hole. Finely inform the SONATRACH supervisor that the hole is clean.

In order to avoid drilling lost time, during run 18’’5/8 Casing the storage system will be prepared to store a volume of 120 m3 of OBM 70/30, 1.25sg received from LMP /HMD, to be used for the drilling of the 16" hole section.

2.1.3. Mud proprieties selection 26":

2.1.3.1. Mud weight:

The mud weight must be maintained as low as possible <1,08sg. The mud weight is extremely important in the effort to minimize the chances of whole mud losses into the formation. In addition, an increase in mud weight reduces the rate of penetration and increases the length of time that the mud is in contact with the formation. The mud weight therefore must be maintained primarily by careful monitoring and control of the Solids Control Equipment, and by dumping solids laden mud and diluting the rest of the fluid system. The use of polymer instead of bentonite for viscosity and filtrate control will aid the reduction in mud weight and therefore maximize the rate of penetration.

2.1.3.2. Rheology:

The Yield Point should be maintained around 50lb/100ft2 to improve a good carrying capacity, before drilling the lost circulation zone through the Limestone and Carbonate interval. Then, it should be decreased progressively to get 35 lb/100ft2 before reaching the casing point depth. The viscosity can be increased using Bentonite and a regular PAC as POLICELL RG but bentonite will increase the mud weight, gels and solids more than regular PAC. Decreases in mud weight should be made by dumping solids laden mud and diluting the mud system with new low viscosity mud.

2.1.3.3. Mud cake & Filtration:

Prior pulling out to run in the 18"5/8 casing, the active system should be treated at 3m before the casing point with 4 kgs/m3 of CMC LVT to reduce the filtrate below 20 ml to ensure wellbore stability and a thin resistant mud cake.

2.1.3.4. Products use:

Table3.1: Products use in the section 26"[36]

Products	**Function**
BENTONITE	Viscosifier, and filtrate Control
CARBONATE DE SOUDE	Calcium Remover
SOUDE CAUSTIQUE	Alkalinity for pH Control
CMC LVT	Fluid loss reducing agent
AVAGUM	GUM GUAR viscosifier
AVADETER	Detergent
ECOLUBE	Lubricant
GRANULAR M/C	L.C.M. Vegetal Shell
AVAMICA M/C	L.C.M. Mica

2.1.3.5. Mud properties:

Table3.2: Mud properties in the section 26" [36]

System	**FRESH WATER-GEL**
Interval(m)	00-513 m
Density (s.g.) in/out	1.05
Funnel Viscosity (sec/qt)	60 – 80
plastic Viscosity (cps)	minimum possible
Yield Point (lb/100ft2)	50
Gels strength 10” (lb/100ft2)	15 – 20
Gels strength 10’ (lb/100ft2)	35 – 40
API filtrate (cc /30 min)	<20 (Before run csg)
PH	10 – 12

Alkalinity mud Pm (cc H2SO4 0.02N)	0.8 – 1.0
Alkalinity mud Pf (cc H2SO4 0.02N)	01 – 0.15
Alkalinity mud Mf (cc H2SO4 0.02N)	0.4 – 0.6
Solides (% by vol)	4 – 6
Sand % en vol	Max 0.5
LGS	< 4.0
MBT (kg/m3)	80 – 100
Ca++	< 0.4

2.1.3.6. Mud formulation: new mixed mud 1.05 sg:

Table3.3: Mud formulation: new mixed mud 1.05 sg in the section 26"[36]

Products	**Kg / m_3**
SODA ASH	0.5
CAUSTIC SODA	1
BENTONITE	80
ECOLLUBE	2
AVADETER	3
CMC LVT (300 m3 to treat)	4

Notes: The mud volumes do not take into account possible lost circulation problems or hole washouts. The maintenance volume includes mud lost on cuttings and through solids removal equipment. This maintenance rate is based on our experience but will vary with formation type, penetration rate, bit selection and the efficiency of the solids control equipment. Mud products delivered to the well site should be covered with heavy duty shrink wrap plastic, and should be stocked on good quality pallets.

2.1.3.7. Solids Control Equipments Recommendations:

The Solids Control Equipment is essential to remove drilled solids and maintain the desired fluids properties. Therefore such equipment, Shakers, Desander, Desilter, and Mud Cleaner must be used with maximum efficiency. Thus, while the actual product concentrations required to build mud are standardized and vary only with the properties desired, the chemical treatment and dilution rates are difficult to predict unless the actual equipment to be used is known, together with the ability of the crew to maximize their efficient use.

2.1.3.7.1. Shale Shakers:

DERRICK: API 50 /or 60 and every screens used, will be mentioned on the DDFR with cost. Dependant on flow rate and fluid properties, the on-site mud engineer will advise on the use of specific screens to match the current situation.

2.1.3.7.2. Mud Cleaner:

One desilter of at least 20x 2 in cones, but preferably a mud cleaner fitted with API 100 or finer if flow rates permit – this will depend on the sizing and effectiveness of the shaker screens.

2.2. Section 16" PROGRAM:

2.2.1. Interval from 513 m TO 2395 m:

We start drilling this section using Avoil DS.IE.70 which is a diesel based invert emulsion system with an oil/water ratio of 70/30, at the end of this section the o/w ratio should be adjusted to 85/15. Oil based mud in this section is recommended to preserve hole stability and maximise drilling performance through this section. Dilution volumes will also be minimized by closely monitoring the performance of the Solids Control Equipment at all times. The objective of this section is to case off the Senonian Salts, to ensure that thereare no freshwater influxes from the Albian formation, and potentially unstable clays.

2.2.2. DISCUSSION:

In order to minimise the effect of swelling clays and to inhibit washouts in the Senonian Salts, an Oil Based mud AVOIL 70/30 is recommended. This will preserve hole stability and maximize drilling performance through these formations of evaporate / anhydrite, and inter-bedded shales.

The mud engineer must use the pit screens to receive the Oil Based mud from mud plant. prior to displace the Water Based Mud by the Oil Based Mud, ensure that the cement is hard.

In order to avoid the mud contamination displace as per SONATRACH procedure to pump 20m3 of water, 5m3 of diesel finely pump the Oil Based Mud.

To drill out the shoe track, the density of the fluid will be 1.25 sg. This will be raise to **1.25 sg** before drilling the **turonien** and kept until section TD unless further increase when hole conditions dictate. With the use of OBM, high penetration rates can be expected, while losses are still a potential issue in this section. At 700m, start to weight up the new mud 90/10 0.90 sg, received from LMP HMD to **2,40 sg**, the final volume obtained 180m3 will be isolated and stored for use in next section. Pulling out the bit, the BHA could be get stuck in the Turonian or the Saliferous formations. For this purpose, and in order to solve the problem, for each formation, as per SONATRCH procedures:

➢Pump a 10 m3 of 15% hydrochloric Acid pill isolated with two diesel spacers of 2 m3 each, while trying to move up and down the BHA, in the Turonian.

Note: Never use the mud pits to store the acid pill.

➢ Pump a 10 m3 of Fresh Water pill isolated with two diesel spacers of 2 m3 each, while trying to move up and down the BHA, in the Saliferous. In this case the Mud Engineer on site must analyze the water and put the results (MW and Salinity) on DDFR.

The Electric Stability should be higher than 600 Volts. Any presence of water into the HP/HT filtrate is the indication of a bad emulsion stability of the system. The treatment should be carried out immediately enough emulsifiers AVOIL PE, AVOIL SE and LIME.

At CSG point, the YP should be treated and reduced to 14lbs/100ft2 using 02kg/m3 of thinner AVOIL TN.

The Mud Engineer must ensure physical monitoring of volumes during all operations: (Run or pooling out of the hole of BHA, cementing job of casing or liner).

During the run casing he uses the electronic file to record and evaluate the loss or gain of mud during this operation. The SONATRACH supervisor must be informed of the situation every 300 meter and any abnormality.

During special operations both mud engineers must be present. Instructions between the senior and junior mud engineer must be written on the register for the award set available on all Mud lab. Strictly prohibits the mud engineer manipulates the valves, down inside to mud pits or drive the different rig gears.

2.2.3. Mud proprieties selection section 16":

2.2.3.1. Mud weight:

The mud weight must be maintained in the range 1,25 sg according to the hole conditions with barite additions and centrifuging as necessary to maintain low gravity solids below 5%. The mud weight is important in order to decrease the chances of hole mud losses into the formation.

In addition, an increase in mud weight reduces the rate of penetration and therefore increases the length of time that the mud is in contact with the formation and the depth of invasion of the filtrate and hence hole stability.

The mud weight should be maintained primarily by using efficient solids control equipment and by running the finest screens possible on the shakers. In order to use the remaining mud for the next section, it is recommended to increase gradually the Oil/Water Ratio to 80/20 before reaching casing point depth.

2.2.3.2. Rheology:

The Yield Point should be maintained around 24-18 lb/100ft2. However, if possible the viscosity of the mud should be maintained within the specified range and the use of viscosified pills should be avoided unless it is believed that the hole is not being cleaned properly (if not enough cuttings coming over the shakers, over pull at connections, excessive drag and torque). Maintained the yield point around 18 lb/100ft2 before run casing. Since any increases in YP also increase the PV which in turn increases pressure loss and hence pump rate, it is important to judge the benefits of increasing the viscosity considering the necessary decrease in pump rates.

2.2.3.3. Mud cake & Filtration:

The filtrate loss is primarily controlled by the emulsion in an oil based system and the quantity of emulsifiers plays an important roll in the rate of filtrate. This control is enhanced by Avoil FRHT Asphalt based filtrate reducer, is added to this system to decrease the rate of filtrate.

The mud-cake quality is controlled by this fluid loss additive and by the concentrations of Avabentoil SA. The filter-cake of the HPHT should always be thin (<1mm).

2.2.3.4. Hole Cleaning:

Poor hole cleaning is indicated by an increase in pump pressure, increased torque and drag, over-pull at connections and by a lack of an appropriate amount of cuttings on the shakers relative to the ROP and hole size. The main ways that the hole cleaning capacity can be improved is by:

- Maximising the pump rate.
- Circulating until the shakers are clean prior to pulling out of hole.
- Increasing the YP and LSYP reading by adding viscosifiers.
- Minimising PV by good solids control and/or increasing the O/W ratio.

Before tripping, the shakers must be circulated clean at normal pump rates while reciprocating the pipe and moving the drill pipe up and down. If there are indications of poor hole cleaning, the drilling rate should be controlled.

2.2.3.5. Products Use:

Table3.4: products use in the section 16"[36]

Products	**Function**
AVABENTOIL SA	Organophylic Clay, Viscosifier
AVOIL PE	Primary Emulsifier
AVOIL SE	Secondary Emulsifier and Wetting Agent
AVOIL FRHT	Asphalt based filtrate reducer
AVOIL WA	Wetting Agent
AVOIL TN	Thinner
AVOIL VS	Synthetic Viscosifier
LIME	Fatty based emulsifiers activor
SODIUM CHLORIDE	Activity Water Control
BARITE	Weighting Agent

2.2.3.6. Mud Properties:

Table3.5: Mud proprieties in the section 16"[36]

System	Avoil DS – IE 70
Interval(m)	513 m - 2395 m
Density (s.g.)	1.25
plastic Viscosity (cps)	minimum possible
RPM 6 @ 120° F	12 – 14
Yield Point (lb/100ft2)	18 – 24
Gels strength 10" (lb/100ft2)	08 – 12
Gels strength 10' (lb/100ft2)	14 – 18
HP/HT Filtrate @ 200°F cc/30min	10 cc
Ratio Oil/Water	70/30
Electric Stability volts	> 600
Alkalinity mud Pm (cc H2SO4 0.02N)	2.0 – 2.5
Excess lime	7.4 – 9.25
NaCl (% by Wt)	26.5%
Solides (% by vol)	16 – 18
Sand % en vol	Max 0.5
LGS	< 5.0

2.2.3.7. Mud formulation:

Table3.6: mud formulation in the section 16"[36]

Products	d=1,25 R H/E=70/30
	Lt or Kg / m3
DIESEL	584Lt
AVABENTOIL SA 10,0	10,0
AVOIL PE	10,0
AVOIL SE	10,0
LIME	30,0
SAUMURE au NaCl / NaCl	264Lt / 95

AVOIL FRHT	0.5
BARITE importée	346

Notes:

- ➢ The mud recovered from vertical cuttings dryer will be reused in this section.
- ➢ The mud volumes do not take into account possible lost circulation problems.
- ➢ For volume hole is taken into account for 7% of washout.
- ➢ The maintenance volume includes mud lost on cuttings and through solids removal equipment.
- ➢ For the volume of coating is estimated at 80% volume drilled.
- ➢ This maintenance rate is based on our experience but will vary with formation type, penetration rate, bit selection and the efficiency of the solids control equipment.

During drilling this section the volumes of OBM received can be adapted to obtain a final Oil/Water ratio at minimum 83/17 at Casing point to start drilling next section with 85/15.

2.2.4. Recommendations for Solids Control Equipment:

The Solids Control Equipment is essential to remove drilled solids and maintain the desired fluids properties. Therefore such equipment, Shakers, Desander, Desilter, and Mud Cleaners and Centrifuges - **must be used with maximum efficiency from beginning to the end of section.** Thus, while the actual product concentrations required to build mud are standardized and vary only with the properties desired, the chemical treatment and dilution rates are difficult to predict unless the actual equipment to be used is known, together with the ability of the crew to maximize their efficient use.

The mud engineer is responsible for all solid control equipments. He must continuously monitor the state of screens.

Cleaning of the shale shakers is in charge of the contractor including the Diesel used.

2.2.4.1. Shale Shakers:

DERRICK:API 80 /API 10, at the beginning of the hole section, care should be taken regarding Shale Shaker screen size and flow rate.

Initially it will take one to two circulations for the mud to fully shear and warm up.

The objective is to prevent losses due to screen blinding. Dependant on flow rate and fluid properties; The on-site mud engineer will advise on the use of specific screens to match the current situation.Every screen used, will be mentioned on the DDFR.

2.2.4.2. Mud Cleaner:

One desilter of at least 20x 2 in cones, but preferably a mud cleaner fitted with 4 x API150 or finer if flow rates permit – this will depend on the sizing and effectiveness of the shaker screens.

2.2.4.3. Centrifuge:

Two fully variable hydraulically driven centrifuges set up in a Barite Recovery System will be on standby for the Mud Engineer to use at his discretion to control both the mud weight and the level of Low gravity 'fines' in the fluid.

Since start drilling, the first centrifuge must be set at high inflow/low speed rotation (low G) in order to strip out the barite discharged which will be returned to the active system; the centrate from this centrifuge is sent to the second centrifuge which is set at low feed/high rotation (high G) in order to discharge the maximum of LGS.

2.3. Section n Ø 12 ¼" PROGRAM:

2.3.1. Interval from 2395 m to 3326 m:

This section will be drilled using AVOIL DS.IE.85 recovered from previous section and newly mixed mud to make up final volume. Oil based mud in this section is recommended to preserve hole stability and maximise drilling performance through this section. The objective of this section is to drill through and case off the over pressured zones, and especially Horizon B limestone which is known to be salt water charged.

2.3.2. Discussion:

During the drilling of previous section (16"), the volume 180 m3 with weight 2,40sg with an oil/water ratio of 90/10 will conditioned and mixed with 63m3 of mud with an oil/water ratio of 83/17 and MW=1,25 sg , to obtain approximately 243 m3 of mud With oil/water ratio 85/15 and MW 2,10sg to start the section.

The Electric Stability should be higher than 1000 Volts. Any presence of water into the HP/HT filtrate is the indication of a bad emulsion stability of the system. The treatment should be carried out immediately enough emulsifiers AVOIL PE, AVOIL SE and LIME.

Prior to displace the light mud by the heavy mud, ensure that the cement is hard. After displacement of mud of previous section with OBM MW = 2,10sg, a volume of 40m3 of mud with MW=2,40sg should be prepared by weighting up 30 m3 1.25sg. Before the shoe bond test the mud engineer must ensure that the mud is homogeneous (MW in = MW out). During the drilling of this section follow the chemical characteristics of the mud mainly Ca++ and Cl. Once we drilled until KOP, during the pooling out of hole of BHA, clean the active system.

Dispose of 100m3 empty pits, to manage any contamination with LD2. After that you must be decrease MW of contaminated mud to 1,50sg and will be back loaded to AVA LMP. During this section we shouldn't pump HI-VIS sweep

The Mud Engineer must ensure physical monitoring of volumes during all operations: (Run or pooling out of the hole of BHA, cementing job of casing or liner). During the run casing use the electronic file to record and evaluate the loss or gain of mud during this operation. The SONATRACH supervisor must be informed of the situation every 300 meter and any abnormality. During special operations both mud engineers must be present. Instructions between the senior and junior mud engineer must be written on the register for the award set available on all AVA Mud lab. Strictly prohibits the mud engineer manipulates the valves, down inside to mud pits or drive the different rig gears.

2.3.3. Mud proprieties selection :

2.3.3.1. Mud Weight:

The mud weight must be maintained around of 2,10 sg according to hole conditions with barite additions and centrifuging as necessary to remove low gravity solids. This high mud weight should be weighted up to 2.10sg to stabilise the over pressured formations (LD 2), and counteract the squeezing of the salt and influx of formation fluids ($CaCl_2$ water and CO_2).

For this reason, pit level must be strictly monitored, and any increase reported immediately. Further, the mud properties (Density, Alkalinity, Chlorides contents, and Electric Stability) must be checked continuously.

The mud weight therefore must be maintained primarily by having excellent Solids Control Equipment, and the finest screens possible on the shakers, and secondly by the use of the centrifuge and thirdly, if necessary by bleeding in newly made lower density mud.

Since start drillig the two centrifuges must be used in series in a barite recovery system. The first centrifuge must be set at high inflow/low speed rotation (low G) in order to strip out the barite discharged which will be returned to the active system; the centrate from this centrifuge is sent to the second centrifuge which is set at low feed/high rotation (high G) in order to discharge the maximum of LGS.

2.3.3.2. Rheology:

The Yield Point should be maintained in the range of 10-14 lb/100ft2 using either Avabentoil SA and adjusting the ratio Oil/Water of the system. However, if possible the viscosity of the mud should be maintained within the specified range and the use of viscosified pills should be avoided unless it is believed that the hole is not being cleaned properly (ie not enough cuttings coming over the shakers, over pull at connections, excessive drag and torque).

Since any increases in YP also increase the PV which in turn increases pressure loss and hence pump rate, it is important to judge the benefits of increasing the viscosity considering the necessary decrease in pump rates.

At CSG point, the mud rheology will be reduced using 2 kg/m3 of thinner Avoil TN (Yp=10-12lb/100ft2).

2.3.3.3. Mud cake & Filtration:

The filtrate loss is primarily controlled by the emulsion in an oil based system and the quantity of emulsifiers plays an important roll in the rate of filtrate. This control is enhanced by Avoil FR/HT Asphalt fluid loss reducer Additive, added to this system to decrease the rate of filtrate.

The mud-cake quality is controlled by this fluid loss additive and by the concentrations of Avabentoil SA. The filter-cake of the HPHT should always be thin (<1mm).

2.3.4. Products Use:

Table3.6: products use in the section 12 ¼" [36]

Products	Function
AVABENTOIL SA	Organophylic Clay, Viscosifier

AVOIL PE	Primary Emulsifier
AVOIL SE	Secondary Emulsifier and Wetting Agent
AVOIL FC	Lignite Based Fluid Loss Additive
AVOIL FR/HT	Asphalt based filtrate reducer
AVOIL WA	Wetting Agent
AVOIL TN	Thinner
AVOIL VS	Synthetic Viscosifier
LIME	Fatty based emulsifiers activor
SODIUM CHLORIDE	Activity Water Control
BARITE	Weighting Agent

2.3.5. Mud Properties:

Table3.7: mud proprieties in the section 12 ¼" [36]

System	Avoil DS – IE 85
Interval(m)	2395 - 3326 m
Density (s.g.)	2.10
plastic Viscosity (cps)	minimum possible
RPM 6 @ 120° F	8 – 12
Yield Point (lb/100ft2)	10 – 14
Gels strength 10" (lb/100ft2)	8 – 12
Gels strength 10' (lb/100ft2)	12 – 16
HP/HT Filtrate @ 200°F cc/30min	10 cc
Ratio Oil/Water	85/15
Electric Stability volts	> 1000
Alkalinity mud Pm (cc H2SO4 0.02N)	2.0 – 2.5
Excess lime	7,4 – 9.25
NaCl (% by Wt)	26,5%
Solides (% by vol)	36 – 38

Sand % en vol	Max 0.5
LGS	< 5.0

2.3.6. Mud Formulation: New Mud 2.10 Ratio Oil/Water 85/15:

Table3.8: mud Formulation: new mud2.1 in the section 12 ¼" [36]

Products	d=2,10 R H/E=85/15
	Lt or Kg / m3
DIESEL	511 Lt
AVABENTOIL SA	8,0
AVOIL PE	10,0
AVOIL SE	10,0
LIME	30,0
SAUMURE au NaCl / NaCl	97,0Lt / 35.0
AVOIL FRHT	1,5
AVOIL WA	2,0
BARITE	1 470,0

Notes:

➢ The mud recovered from vertical cuttings dryer will be isolate & cut MW=1.50sg, after that will be back load to LMP HMD

➢ The mud volumes do not take into account possible lost circulation problems.

➢ **For volume hole is taken into account for 7% of washout.**

➢ The maintenance volume includes mud lost on cuttings and through solids removal equipment.

➢ For the volume of coating is estimated at 80% volume drilled.

➢ This maintenance rate is based on our experience but will vary with formation type, penetration rate, bit selection and the efficiency of the solids control equipment.

2.3.7. Recommendations for Solids Control Equipment:

2.3.7.1. Shale Shakers:

DERRICK: API 120, at the beginning of the hole section, care should be taken regarding Shale Shaker screen size and flow rate. Initially it will take one to two circulations for the mud to fully shear and warm up. It will be necessary to start out with larger than desired screens on the shakers. The objective is to prevent losses due to screen blinding.

Dependant on flow rate and fluid properties, the on-site mud engineer will advise on the use of specific screens to match the current situation.

2.3.7.2. Mud Cleaner:

One 20 x 2 in cones mud cleaner fitted with 2 HP 180+2 HP 100 or finer if flow rates permit; this will depend on the sizing and effectiveness of the shaker screens.

Adjust screen size as required to minimise any whole mud losses during this section.

The feed head is not as critical since actual solids removal is governed by the screen size and not the hydro cyclone performance.

2.3.7.3. Centrifuge:

Two fully variable hydraulically driven centrifuges set up in a Barite Recovery System will be on standby for the Mud Engineer to use at his discretion to control both the mud weight and the level of Low gravity ‘fines’ in the fluid. Since Start drilling, the first centrifuge must be set at high inflow/low speed rotation (low G) in order to strip out the barite discharged which will be returned to the active system; the centrate from this centrifuge is sent to the second centrifuge which is set at low feed/high rotation (high G) in order to discharge the maximum of LGS.

2.4. Section Ø 8" 1/2 PROGRAM:

2.4.1. Interval from 3326 m to 3456 m:

This section will be drilled using AVOIL DS IE 85 which is a diesel based invert emulsion system with MW 1,45sg Oil based mud in this section, is recommended to preserve hole stability.

2.4.2. Discussion:

During drilling of this section, it is recommended to keep a 40 m3 heavy mud at density 2,40 sg to be used as kill-mud. 135 m3 of mud recovered from previous sections which has been treated by dilution using 160 m3 of OBM 90/10 with density 0.90sg to obtain 295m3 With MW=1.45 sg.

During drilling out 9 ⅝" casing shoe, the hole volume will be displaced with the new mixed mud.

Continue dilute the mud of last section & backload it to LMP HMD. Don't unload any volume of Heavy mud without SONATRACH FC superintendant agreement.

The Mud Engineer must ensure physical monitoring of volumes during all operations: (Run or pooling out of the hole of BHA, cementing job of liner).During invert circulation must evaluate the cement and spacer volume that return to surface. During the run Liner he uses the electronic file to record and evaluate the loss or gain of mud during this operation. The SONATRACH supervisor must be informed of the situation every 100 meter and any abnormality. During special operations both mud engineers must be present. Instructions between the senior and junior mud engineer must be written on the register for the award set available on all Mud lab. Strictly prohibits the mud engineer manipulates the valves, down inside to mud pits or drive the different rig gears Continue dilute the mud of last section & backload to LMP HMD.

2.4.3. Mud proprieties:

2.4.3.1. Mud Weight:

The mud weight must be maintained around of 1.45 sg according to hole conditions with barite additions and centrifuging as necessary to remove low gravity solids. The mud weight therefore must be maintained primarily by having excellent Solids Control Equipment, and the finest screens possible on the shakers, and secondly by the use of the centrifuge and thirdly, if necessary by bleeding in newly made lower density mud.

Since the mud weight is high, the two centrifuges must be used in series in a barite recovery system. The first centrifuge must be set at high inflow/low speed rotation (low G) in order to strip out the barite discharged which will be returned to the active system; must be set at high inflow/low speed rotation (low G) in order to strip out the barite discharged which will be returned to the active system; the centrate from this centrifuge is sent to the second centrifuge which is set at low feed/high rotation (high G) in order to discharge the maximum of LGS.

2.4.3.2. Rheology:

The Yield Point should be maintained in the range of 10 to 12 lb/100ft2 using either Avabentoil SA and adjusting the ratio Oil/Water of the system. However, if possible the viscosity of the mud should be maintained within the specified range and the use of viscosified pills should be avoided unless it is believed that the hole is not being cleaned properly (ie not enough cuttings coming over the shakers, over pull at connections, excessive drag and torque). Before start run 7" casing, the mud rheology will be reduced using 2 kg/m3 of thinner Avoil TN.

2.4.3.3. Mud cake & Filtration:

The filtrate loss is primarily controlled by the emulsion in an oil based system and the quantity of emulsifiers plays an important roll in the rate of filtrate. This control is enhanced by Avoil FRHT asphalt Based Fluid Loss reducer Additive, added to this system to decrease the rate of filtrate. The mud-cake quality is controlled by this fluid loss additive and by the concentrations of Avabentoil SA. The filter-cake of the HPHT should always be thin (<1mm).

2.4.3.4. Products Use:

Table3.9: products use in the section Ø 8" 1/2[36]

Products	**Function**
AVABENTOIL SA	Organophylic Clay, Viscosifier
AVOIL PE	Primary Emulsifier
AVOIL SE	Secondary Emulsifier and Wetting Agent
AVOIL FRHT	Asphalt based filtrate reducer
AVOIL WA	Wetting Agent
AVOIL TN	Thinner
AVOIL VS	Synthetic Viscosifier
LIME	Fatty based emulsifiers activor
SODIUM CHLORIDE	Activity Water Control
BARITE	Weighting Agent

2.4.3.5. Mud Parameters:

Table3.10: mud proprieties in the section Ø 8" 1/2[36]

System	**Avoil DS – IE 85**
Interval(m)	3326 -3456m
Density (s.g.)	minimum possible
plastic Viscosity (cps)	1.45
RPM 6 @ 120° F	5 – 7
Yield Point (lb/100ft2)	10 – 12
Gels strength 10” (lb/100ft2)	6 – 8
Gels strength 10’ (lb/100ft2)	8 – 12
HP/HT Filtrate @ 200°F cc/30min	10
Ratio Oil/Water	85/15
Electric Stability volts	> 1000
Alkalinity mud Pm (cc H2SO4 0.02N)	2.0 – 2.5
Excess lime	7,4 – 9.25
NaCl (% by Wt)	26.5%
Solides (% by vol)	20 – 22
Sand % en vol	Max 0.5
LGS	< 5.0

2.4.3.6. Mud Formulation: New Mixed Mud 1.45 Ratio Oil/Water 85/15:

Table 3.11: mud formulation: new mud 1.45 in the section Ø 8" 1/2[36]

Products	d=1.45 R H/E=85/15 Lt or Kg / m_3
DIESEL	718 Lt
AVABENTOIL SA	15,0
AVOIL PE	8,0
AVOIL SE	8,0
LIME	30,0

SAUMURE au NaCl / NaCl	30,0
Industriel water	83
AVOIL FRHT	2.5
BARITE	618

2.4.3.7. Recommendations for Solids Control Equipment:

2.4.3.7.1. Shale Shakers:

DERRICK: HP 4 x 140, at the beginning of the hole section, care should be taken regarding Shale Shaker screen size and flow rate. Initially it will take one to two circulations for the mud to fully shear and warm up. It will be necessary to start out with larger than desired screens on the shakers. The objective is to prevent losses due to screen blinding. Dependant on flow rate and fluid properties, the on-site mud engineer will advise on the use of specific screens to match the current situation.

2.4.3.7.2. Mud cleaner:

A 20x 2 in cone mud cleaner fitted with 4 x180 or finer if flow rates permit. Adjust screen size as required to minimise any whole mud losses during this section. The feed head is not as critical since actual solids removal is governed by the screen size and not the hydro cyclone performance. Impeller size in the feed pump may need to be reduced when used in processing high weight mud. This is due to the increased HP requirements and the need for a better discharge to enhance screen performance.

2.4.3.7.3. Centrifuge:

Two fully variable hydraulically driven centrifuges set up in a Barite Recovery System will be on standby for the Mud Engineer to use at his discretion to control both the mud weight and the level of Low gravity ‘fines’ in the fluid. Since start drilling, the first centrifuge must be set at high inflow/low speed rotation (low G) in order to strip out the barite discharged which will be returned to the active system; the centrate from this centrifuge is sent to the second centrifuge which is set at low feed/high rotation (high G) in order to discharge the maximum of LGS.

2.5. Section Ø 6"PROGRAM:

2.5.1. Interval from 3456 m to 4032m:

This section will be drilled using non damaging AVOIL DS IE 95, which is a diesel based invert emulsion system. In order to avoid formation damage and to ensure maximum well productivity is achieved, the mud weight will be adjusted with AVACARB (sized Calcium Carbonate).

The product is used as non-damaging lost circulation and bridging material which has a particle distribution providing a very thin impermeable cake easily removable.

2.5.2. Discussion:

Before start drilling, a heavy mud on the well will be displaced by a new mud received from LMP. The mud weight for this section will be give by SH/DP

The Mud Engineer must ensure physical monitoring of volumes during all operations: (Run or pooling out of the hole of BHA, cementing job of liner).During invert circulation must evaluate the cement and spacer volume that return to surface. The degasser must be tested every day. To ensure that it have on location minimum 100 tonnes of BARITE and 30m3 of Kill mud MW=2,40sg.

During the run Liner he uses the electronic file to record and evaluate the loss or gain of mud during this operation. The SONATRACH supervisor must be informed of the situation every 100 meter and any abnormality.

During special operations both mud engineers must be present. Instructions between the senior and junior mud engineer must be written on the register for the award set available on all Mud lab. Strictly prohibits the mud engineer manipulates the valves, down inside to mud pits or drive the different rig gears.

2.5.3. Mud proprieties:

2.5.3.1. Rheology:

The Yield Point should more or less than 12 lb/100ft2 by using either Avabentoil SA and/or Avoil VS. The shakers must always be regularly checked in order to make sure that the amount of cuttings being stripped out is relative to the drilling rate and volume of formation being drilled. The Fann 6 reading is the best value for the shear rates in the annulus where shear values are relatively low.

Note: For ensure a good conditions of the hole cleaning we must pump Low-Vis (YP~ 3 to 4 lb/100ft2) followed by Hi-vis pill (Y~ 30-40 lb/100ft2) every length. The volume of each pill is (3m3 each one).

Hi-vis pill Formulation: (To obtain a yield point between 30 and 40 lb/100ft2.**)**

Table3.12 : HI-VIS PILL FORULATION [36]

Products	**Quantity kg/ m3**
AVABENTOIL HY	30.00
AVABENTOIL SA	25.00
AVOIL VS	04.00

2.5.3.2. Mud cake & Filtration:

The filtrate loss is primarily controlled by the small particles of water in an oil based system and the quantity of emulsifiers plays an important role in the amount of filtrate. However Avoil FC, a Lignite Based Fluid Loss Additive or avoil FR/ND is also added to this system to decrease the amount of filtrate.

The mud-cake quality is controlled by this fluid loss additive and by the concentrations of Avabentoil SA. The filter-cake of the HPHT should always be thin (<1mm).

2.5.3.3. Hole Cleaning:

Poor hole cleaning is indicated by an increase in pump pressure, increased torque and drag, over-pull at connections and by a lack of an appropriate amount of cuttings on the shakers relative to the ROP and hole size. The main ways that the hole cleaning capacity can be improved is by:

- Maximising the pump rate;
- Circulating until the shakers are clean prior to pulling out of hole;
- Increasing the YP and Fann 6 reading by adding viscosifiers;
- Minimising PV by good solids control and/or increasing the O/W ratio.

Before tripping, the shakers must be circulated clean at normal pump rates while reciprocating the pipe and moving the drill pipe up and down. If there are indications of poor hole cleaning, the drilling rate should be controlled and high viscosified pills and low viscosified pills should be pumped.

2.5.3.4. Products Use:

Table3.13: products use in the section Ø 6" [36]

Products	Function
AVABENTOIL SA	Organophylic Clay, Viscosifier
AVOIL PE	Primary Emulsifier
AVOIL SE	Secondary Emulsifier and Wetting Agent
AVOIL FC	Lignite Based Fluid Loss Additive
AVOIL WA	Wetting Agent
AVOIL TN	Thinner
AVOIL VS	Synthetic Viscosifier
LIME	Fatty based emulsifiers activor
SODIUM CHLORIDE	Activity Water Control
INTASOL F/M/C	Sized Calcium Carbonate for Seepage Losses

2.5.3.5. Mud Parameters:

Table3.14: mud parameters in the section Ø 6"[36]

System	Avoil DS – IE 95
Interval(m)	3456 – 4032
Density (s.g.)	As Per SH/DP
plastic Viscosity (cps)	minimum possible
Yield Point (lb/100ft2)	12
LSYP@ 150°F (lb/100ft2)	6 – 10
Gels strength 10” (lb/100ft2)	4-8
Gels strength 10’ (lb/100ft2)	10-12

HP/HT Filtrate @ 200°F cc/30min	<4
Ratio Oil/Water	95/05
Electric Stability volts	> 1000
Alkalinity mud Pm (cc H2SO4 0.02N)	1.0 – 1.5
Excess lime	3.7 – 5.55
NaCl (% by Wt)	26.5%
Solides (% by vol)	Depending on MW
Sand % en vol	Max 0.5
LGSD	< 3.0

2.5.3.6. Mud Formulation: New Mixed Mud 0.8 Ratio Oil/Water 95/05:

Table 3.15: mud formulation: new mud0.8 in the section Ø 6"[36]

Products	**Lt or Kg / m3**
DIESEL	882
AVABENTOIL HY	38
AVOIL PE	6
AVOIL SE	6
LIME	25
Sodium chloride (NaCl)	18
Water	84
AVOIL FC	35

Notes:

➢ The mud volumes do not take into account possible lost circulation problems.

➢ For volume hole is taken into account for 7% of washout.

➢ The maintenance volume includes mud lost on cuttings and through solids removal equipment.

➢ For the volume of coating is estimated at 80% volume drilled.

➢ This maintenance rate is based on our experience but will vary with formation type, penetration rate, bit selection and the efficiency of the solids control equipment.

➢ Estimated reception of OBM for this section @ MW 1.30sg is based approximatively on offset wells, depend on SH DP this MW can be changed to required one.

2.5.4. Recommendations for Solids Control Equipment:

2.5.4.1. Shale Shakers:

DERRICK: HP 4 x 140, at the beginning of the hole section, care should be taken regarding Shale Shaker screen size and flow rate. Initially it will take one to two circulations for the mud to fully shear and warm up. It will be necessary to start out with larger than desired screens on the shakers. The objective is to prevent losses due to screen blinding. Dependant on flow rate and fluid properties, the on-site mud engineer will advise on the use of specific screens to match the current situation.

3. Comparison of the results:

3.1. The density:

The density is one of the main parameter of drilling to avoid problems, counterbalance the formation pressure and also to keep wellbore in good conditions. The density is estimated by the seismic operations before drilling for each formation, the estimation of the formation pressure leads to the density by the equation d= $\frac{p\times 10.2}{z}$.
After, drilling operation starts, watching the back flow ratio and mud pits level to notice if there is any gain or loss, in case of loss they must decrease the density, and in case of gain they must decrease the density. Before start drilling a new phase, a leak of test must be done to determinate the accurate value of the drilling mud density, the fracture density, and also the maximum allowed surface casing pressure.
Leak of test is a test based on increasing the bottom hole pressure by pamping in a closed well, and following the pressure gauge while pumping to notice any dropping in the pressure, in the drop point the well start leaking in the formation, we must stop the pumps and bleed of the pressure and calculate the :

Fracture pressure= $\frac{Zs\times dlot}{10.2}$ + Plot

$d_{fr} = \frac{\mathbf{FP\times 10.2}}{\mathbf{z}}$ MASCP= FP-HP

3.2. The viscosity:

The viscosity is the main parameter that carry on the cutting from the bottom hole to the surface, we must insure that during drilling we have good viscosity value, in the laboratory they made experiences for each section to determinate the perfect viscosity which shouldn't be that big leading to huge pressure and shouldn't be that small to have disability in carrying of cutting.

Determinating the value of any viscosity is depending essentially in the hole section, more hole section is, more cutting amount, more viscosity value. The funnel viscosity should be always between 60-80 (sec/qt), to keep the mud pump pressure under control and in resonable intervals that's why we see in our research that most values of viscosity are decreasing as the phase decrease.

In the section 26" Funnel Viscosity is 60 – 80 (sec/qt) , Yield Point is 50 (lb/100ft2) and the Gels strength 10" is 15 – 20 (lb/100ft2).

In the section 16" Funnel Viscosity is 60 – 80 (sec/qt) , Yield Point is 18 – 24 (lb/100ft2) and the Gels strength 10" is 08 – 12 (lb/100ft2).

in the section 12 ¼" Funnel Viscosity is 60 – 80 (sec/qt) , Yield Point is 10 – 14 (lb/100ft2) and the Gels strength 10" is 8-12 (lb/100ft2).

use in the section Ø 8 ½" Funnel Viscosity is 60 – 80 (sec/qt) , Yield Point is 10 – 12 (lb/100ft2) and the Gels strength 10" is 6 – 8 (lb/100ft2).

We can remarque how all this values are going down following the hole section

3.3. The PH:

The PH should be always up to 9 if it goes down the drill pipe and all the tools will wash out so quick and we can have a fracture or a fail in the drill string that's the reason why it should be always in the base part and more than 9 no matter which section are we in.

Conclusion

Conclusion

Technology to drill holes and to excavate tunnels and openings in rock is vital for the economic, environmental, and scientific well-being of the United States. Drilling is a key technology in several applications of strategic or societal importance, including energy and mineral production, environmental protection, and infrastructure development. During this century, U.S. technology has dominated the worldwide drilling industry and much of the excavation and commination industries. In the committee's view, this U.S. dominance is likely to erode without continued technological advances.

Although incremental improvements in the component processes in the present state of the art can continue to make drilling more productive, it is the basic conclusion of this committee that revolutionary advances are within reach through the introduction and concerted development of smart drilling systems. A smart drilling system is one that is capable of sensing and adapting to conditions around and ahead of the drill bit to reach desired targets. This system may be guided from the surface, or it may be self-guided, utilizing a remote guidance system that modifies the trajectory of the drill when the parameters measured by the sensing system deviate from expectations.

The smart drilling system does not currently exist, but it is presaged by recent dramatic advancements in directional drilling and measurement-while-drilling technologies. Rapid innovation in microelectronics and other fields of computer science and miniaturization technology holds the prospect for greater improvements even revolutionary breakthroughs in these systems.

The development of smart drilling systems has the potential to revolutionize drilling. Research in this area will have a significant impact on drilling success and overall cost reduction. Such "smart" systems are increasingly needed to overcome the drilling challenges posed by small, elusive, easily damaged subsurface targets. This is particularly true in applications where identification of small or difficult-to-predict drilling targets and formation damage are key issues in drilling success.

Bibliography

[1] Baroid advanced mud school blcok 1 @2016.
[2] Baroid advanced mud school block 2 @2016.
[3] Baroid basic mud school 2015-2016.
[4] Participant guide block1 baroid training development program February 2014.
[5] Saudi ARAMCO drilling mud manual may 1999.
[6] Recommended practice for field testing oil-based drilling fluids, API recommended fifth edition, April 2014.
[7] Liquid drilling system 2011.
[8] Drilling fluids technology continuing education, training department Houston, Texas June 9th 2000.
[9] M-I fluid systems and individual products @2000 litho in USA.
[10] Work over and completion fluid.
[11] Geology January 20th, 1997.
[12] Drilling engineering workbook, a distributed learning course baker Hughes inteq, December 1995.
[13] Baroid basic mud school 2013-2014.
[14] Baroid basic mud school 2014-2015.
[15] Water and oil based drilling fluid e-course Halliburton, Houston, USA.
[16] Introduction to drilling fluid e-course Halliburton, Houston, USA.
[17] Baroid family of fluids e-course Baroid Halliburton, Houston, USA.
[18] Physical test &properties? Baroid drilling fluid e-course, Houston, USA.
[19] Clay chemistry & clay states? Baroid drilling fluid, Houston, USA 2010.
[20] Contaminants, Baroid training center? A Halliburton company e-course, Houston, USA.
[21] Composition and Properties of Drilling and Completion Fluids, Sixth Edition 2011 Ryen Caenn, H. C. H. Darley, George R. Gray.
[22] Vertical well drilling program, oil producer, weatherford –IDS /SH-DF 08/07/2007.
[23] Surface data logging manual Sperry-sun training department January 1999.
[24] Fluid manual, direction production, division drilling 1988.
[25] Martial AVA chemical and physic REV N A0 03/31/1998.
[26] La guerre secrete du petrole, JACQUE BERGIER ET BERNARD THOMAS edition denoel, 1968.
[27] Formulas and calculation for drilling, production and work over, NORTON J.LAPEYROUSE.
[28] Drilling data handbook fifth edition 1999.
[29] Baroid fluid services handbook, Halliburton fluid system 02/08/2007.
[30] Bit balling AVA handbook WH/AP-08.

Index

1.1. Introduction:

The Hassi Messaoud (HMD) structure lies approximately 800 km southeast of Algiers, Algeria. It is a flattened, broad, oval anticline trending north- northeast to south-southwest, parallel to the major fault zone.

It covers almost 2,000 Km² in the Oued Mya basin. The first well, MD1 was drilled in 1956 and more than 1,000 wells have been drilled over the last 40 years. The field has been subdivided into 25 zones based on observed inter well pressure communication, the reservoir is in the Cambrian subdivided into four lithozone Ri, Ra, R2, and R3.

1.2. The geographical situation:

Hassi Messaoud is located 800 km southeast of Algiers, between the meridians 5°30 6°00 and the parallels 31°00 and 32°00N (Figure4.1). It is 350km far from the Algero-Tunisian frontier and 80 km east of Ouargla. It is considered to be one of the largest oil deposits in the world and the more prospected of the Saharan platform.

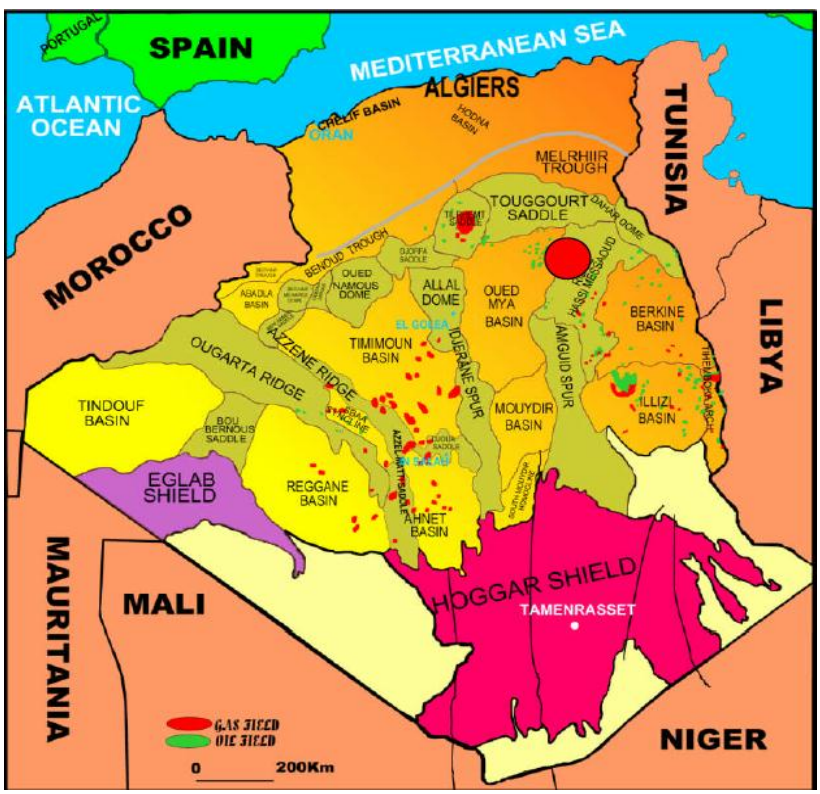

Figure 4.1: Location of Hassi Messaoud Field-Algeria-

1.3. Structure and stratigraphy:

The Saharan desert within the so-called Triassic Basin (Oued Mya Basin) is part of the North African stable craton. The basin has had a long history from Cambrian times onwards, and has a sedimentary column of about 5,000 m (Figure4.2). The Cambrian sediments are a thick series of fluvial and shallow marine sandstones, deposited on a peneplained surface composed, in the Hassi Messaoud area, of Early Cambrian granites. The Algerian Sahara was invaded by a relatively deep anoxic sea during the Ordovician, but this was followed by a regional regression and a period of coarse clastic, continental and glacial sedimentation. During the Late Silurian, deep marine conditions once again occurred over a wide area in North Africa, but the Caledonian orogeny led to the creation of a number of gentle, regional uplifts. Devonian sandstones and shales were deposited extensively in fluvial and shallow marine environments over much of North Africa, including Algeria, and lie unconformable on tilted and eroded Lower Paleozoic sediments. They were followed by deltaic and marine sandstones and shales of Carboniferous age. It is not known for certain whether these Upper Paleozoic sediments were deposited over the Hassi Messaoud high because they have not been preserved there. They may have been deposited with a reduced thickness, but in any case would have been subsequently removed as a result of the tectonic upheavals related to the Hercynian orogeny of Late Carboniferous to Permian times. The grain of the Hercynian orogeny in the Hassi Messaoud area is oriented mostly NE-SW, as is typically seen in the trend of the Messaoud - El Agreb.

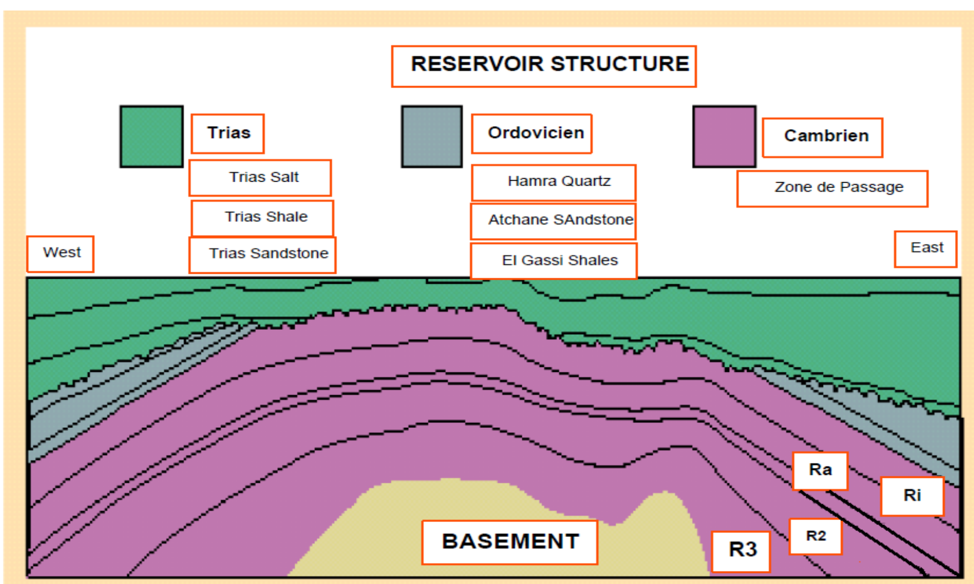

Figure 4.2: Hassi Messaoud Reservoir Structure

The productive formation of Hassi Messaoud is a series of Cambrian sandstones, with an average thickness of 300 m and 4 productive zones denominated R3, R2, Ra, Ri (from bottom to top). The Ra represents the best reservoir qualities. The Paleozoic of Hassi Messaoud has been eroded by the Hercynian unconformity which reaches the R2 in places. This erosion is increasingly important from the periphery to the center where the Ra is locally absent. Structurally, only the top of R2 allows us to correctly define the geometry of the Cambrian of Hassi Messaoud (Figure4.3). The Hassi Messaoud structure appears as a large SSW-NNE Oriented anticline, affected by the major faults SSW-NNE.

- **R3 lithozone:** Non-producing zone with a very low permeability and a high clay content averaging 30 % (illite predominantly). The R3 section thickness increases from 275 m (902 ft) in well Md2 in the south central part of the field northward to 368 m (1207 ft) in well Omg57 north of the field.
- **R2 lithozone:** It has high clay content, averaging 20%, mainly illite with minor amount of kaolinite, occurring as interstitial clay and irregular thin inter beds of shale. R2 is a thick sequence of medium to coarse-grained sandstones. It has a good reservoir quality in the northern part of the field where water saturation is low. The R2 is considered the lower boundary for the net interval due to the proximity to the water oil contact (WOC). R2 is subdivided into two layers: The upper R2 (R2-r1), and the lower R2 (R2-r2). R2-r1 has in general better reservoir characteristics than the latter. Where it is not eroded, R2 zone is about 80 m (262 ft) thick.
- **Ra (anisometric zone):** The Ra zone has a maximum total thickness of 150 m (492 ft) in the western portion of the field, and it is considered as the primary reservoir. The Ra zone is fine-grained quartzite sandstone. Ra zone has been subdivided into five subzones highly laminated with silts and black shale, that are, from the upper to the lower: D4, D3, D2, ID, and D1. The predominant clay mineral in Ra is kaolinite. D5, D4, and D3 drains are eroded in the central northern portions of the field.
- **Ri (isometric zone):** Also referred to as D5, is a 50 m (164 ft) thick quartzitic sandstone unit. It is characterized as a uniformly thick, well sorted, medium grained sandstone with inter beds of shale and siltstone. D5 is not considered as a significant producing zone because of its poor reservoir characteristics. The predominant clay mineral in layer D5 is illite.

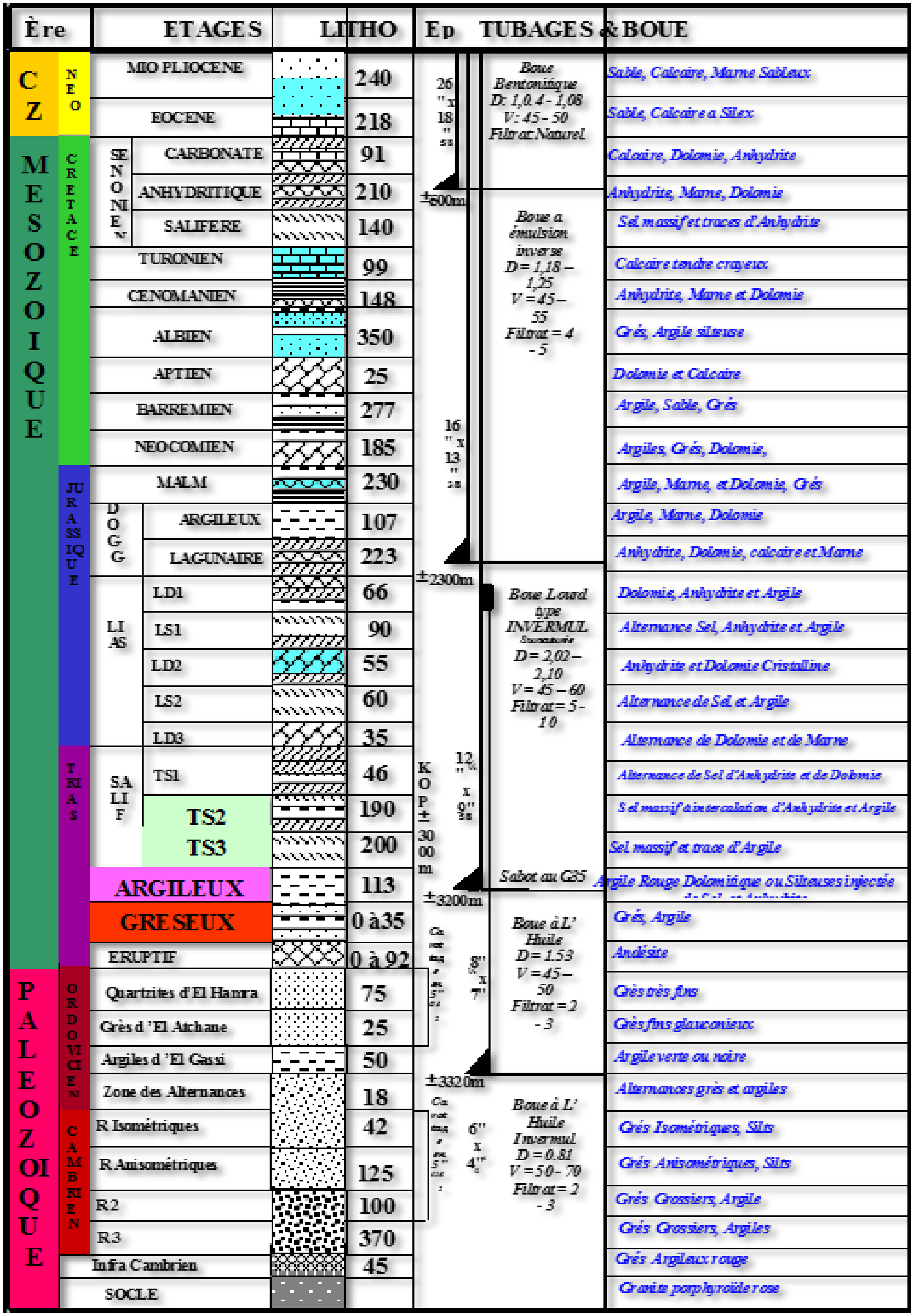

Figure 4.3: Stratigraphic Section of Hassi Messaoud Field

1.4. Petrophysical characteristics:

The base of the Cambrian reservoir is made of coarse to micro-conglomeratic sandstones inter bedded with highly fissured conglomerates. The grain size decreases from the bottom towards the top (60% to 75% in the R3, 90% to 95% in the Ri). The different parts of the Cambrian may be described as follows (Figure4.4):

➢The R3 is composed of coarse sandstones and conglomerates, with cement made of clay and dolomite. The clay is mainly Illite. The porosity varies from 5% to 10%. And permeability is in the range of below 10 md.

➢The R2 is made of sandstones which are coarse but smaller sizes grain than do those in the R3. The cement is argillaceous (Kaolinite). The porosity varies from 10% to 13% and permeability is normally below 10 md.

➢ The Ra is characterized by the interstratification of sandstones and quartzites of variable grain size with shale beds. The cement is argillaceous (dickite). The Ra represents the best petro physical properties with porosity up to 15% and permeability of up to 1 Darcy where fissures exist.

➢ The Ri is made of fine rounded, isometric sandstone with considerable development of quartzite. The porosity varies from 5% to 10%. And permeability is in the range of below 10 md.

TYPE OF CORRELATION			THICKNESS (m)	DRAINS
CAMBRIAN RESERVOIR	Altern. Zone		19	
	R_1	R_{iso}	38	D_5
		Ra	Variable	D_4
			24	D_3
			24	D_2
			30	ID
			27	D_1
	R_2	R_2-r_2 R_2-r_1	14	C
			19	
			20	
			15	
			15	
	R_3		300	

Figure 4.4: Cambrian Reservoir Lithozones

The oil is under saturated and light. It contains no sulfur and has a density of 0.8 at surface. Its composition differs slightly from one zone to another.

- The oil viscosity at surface is 2 cp.
- The oil saturation is up to 85%.
- The reservoir temperature is 118 C.
- The oil FVF is 1.6 -1.7.
- The bubble point pressure is between 155 and 200 kg/cm2.
- The maximum porosity of all these reservoirs is approximately 15 %.
- The permeability varies from 0.5 to 1000 md in the fissured zones.

Salinity of connate water varies from one zone to another but is constant over large interval.

التلخيص

في عمليات الحفر البترولية ، تشكل تشكيلات الصخور المتقاطعة مشكلات في حلها حيث ترتبط ارتباطًا وثيقًا بفهم تفاعلات السوائل الصخرية. بسبب عدم كفاءة أداء السوائل المائية (WBM) التي تواجه مشاكل الصخر الزيتي ، السوائل الزيتية (OBM) منحت تحسينات كبيرة. ومع ذلك ، فإن مفتاح الصعوبة يكمن في علاج التلوث الناجم عن هذه السوائل. الحاضر يعتزم العمل لمقارنة الحد الأقصى من البيانات المختبرية مع البيانات الميدانية الفعلية و نأمل أن يجلب مساهمة في حل المشاكل العملية.

Résumé

Lors des forages pétroliers, la traversée des formations argileuses pose des problèmes dont la résolution est étroitement liée à la compréhension des interactions argile -fluide de forage. Vu les imperfections des fluides à base d'eau (WBM) face aux problèmes des argiles, les systèmes de fluides émulsionnés à base d'huile (OBM) ont apporté des améliorations significatives.

Abstract

In petroleum drilling operations, crossing shale formations poses problems whose solution is strongly related to the understanding of shale -drilling fluid interactions. Due to the lack of performances of water-based fluids (WBM) faced with shale problems, emulsified oil based fluids (OBM) afforded significant improvements. However, the main technical difficulty lies in the treatment of the pollution generated by these emulsions.