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MEMORIE

To Obtain The Diplomat Of Master

Branch: Hydrocarbures

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THÈME

Improving The Hole Cleaning By Amelioration Of Drilling Fluids Conditions

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2023-2024

Our Thanks To

لله وحده لا شريك له له الحمد و الفضل و له الثناء الحسني

قال رسول الله ﷺ

"من لا يشكر الناس لا يشكر الله"

الحمدلله الذي وفقنا لهذا وسخر لنا ما استلزمه هذا العمل

To our families, who provided love, support, and guidance every step of the way, thank you for believing in us and shaping our values.

To our teachers and mentors, who imparted knowledge, wisdom, and inspired us to dream big, thank you for your dedication and encouragement.

To our friends, who shared laughter, tears, and unforgettable moments, thank you for your friendship and unwavering support.

To every person who has crossed our path, leaving a mark on our journey, thank you for your kindness, lessons, and presence in our lives.

Your contributions, big and small, have helped mold us into the people we are today. we are grateful for each of you and the role you have played in our life's story.

Thank you for being a part of our journey!!!!

DEDICATION

To my father & mother, my family….

Am so grateful to keep up with my foolishness my stubbornness and my sometimes-obnoxious behavior, I am what I am

I will keep trying to be a better man for myself and for you guys

To my Friends….

Thank you for a great 5 years of friendship, brotherhood & some amazing adventures.

Its been an honor to study with you guys and to share & make many fond memories

To you, my deepest thanks

-Cherif Ahmed Abderrahmane

DEDICATION

I dedicate this modest work to:

To my dear parents; who never hesitated to provide me with love, support, guidance and comfort.

To my dear mother the candle that lights my path; to the one who constantly supported me you are my guide when I get lost; I hope that through this modest work you will find my deep gratitude.

To my father my example of strength and modesty; for his encouragement; sacrifices and moral and material support.

To my dear brother Amjed and my sister for their moral support and for their joy of living.

To the little princess of the family Daline for her innocence and joy.

To the colleague from the domain Anfel.

To the family Ben Makhlouf and the family Hadfani.

To all my close friends and teachers since the beginning of my academic career.

At the end I warmly dedicate this dissertation to my colleagues Ahmed and Karim.

«(…)Believing in something is first and foremost never giving up on it »

DEDICATION

To those who believed in me and supported me on my academic journey:

- ***My parents:*** *Thank you for your unwavering love and sacrifices. You are my inspiration and the driving force behind my success.*
- ***My family and siblings:*** *Thank you for your constant presence and encouragement. You are my pillars of strength and my source of joy.*
- ***My friends:*** *Thank you for your friendship and shared memories. You are my second family.*
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This achievement is a testament to your faith in me and your unwavering support. Thank you from the bottom of my heart.

With love and gratitude,

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Abstract

Wellbore cleaning is an essential operation in the oil and gas drilling process, ensuring the removal of drilling fluids, cuttings, and other debris from the wellbore. Improper cleaning can lead to a range of issues that hinder drilling operations, including partial or complete stuck pipe, increased friction, and reduced drilling efficiency.

This study aims to investigate the rheological, physical properties, and behavior of drilling fluids and their impact on the cleaning process during the 16-inch phase. The primary objectives are to understand the mechanisms that govern the behaviour of rock cuttings in wellbores & to identify and optimize parameters that facilitate the effective removal of cuttings from the wellbore & to prevent problems arising from inadequate wellbore cleaning.

Key words : Hole cleaning, rheological properties, drilling fluid.

Résumé

Le nettoyage des puits de forage est une opération essentielle dans le processus de forage pétrolier et gazier,assurer l'élimination des fluides de forage, des déblais et autres débris du puits de forage. Un nettoyage inapproprié peut entraîner une série de problèmes qui entravent les opérations de forage, notamment des tuyaux coincés partiellement ou complètement, une friction accrue et une efficacité de forage réduite.

Cette étude vise à étudier les aspects rhéologiques, propriétés physiques et comportement des fluides de forage et leur impact sur le processus de nettoyage pendant la phase 16 pouces. Les principaux objectifs sont Comprendre les mécanismes qui régissent le comportement des déblais de roche dans le puits de forage & Identifier et optimiser les paramètres qui facilitent l'élimination efficace des déblais du puits de forage & Prévenir les problèmes résultant d'un nettoyage inadéquat du puits de forage.

Mots clés : Nettoyage de puits, les caractéristiques rhéologiques, fluide de forage.

الملخص

يعد تنظيف حفرة البئر عملية أساسية في عملية التنقيب عن النفط والغاز، التأكد من إزالة سوائل الحفر والقطع وغيرها من الحطام من حفرة البئر. يمكن أن يؤدي التنظيف غير السليم إلى مجموعة من المشكلات التي تعيق عمليات الحفر، بما في ذلك الأنابيب العالقة جزئيًا أو كليًا، وزيادة الاحتكاك، وانخفاض كفاءة الحفر.

تهدف هذه الدراسة إلى التحقيق في الريولوجية ، الخواص الفيزيائية وسلوك موائع الحفر وتأثيرها على عملية التنظيف خلال مرحلة الـ 16 بوصة. الأهداف الأساسية هي فهم الآليات التي تحكم سلوك القطع الصخرية في حفرة البئر وتحديد وتحسين المعلمات التي تسهل الإزالة الفعالة للقطع من حفرة البئر ومنع المشاكل الناشئة عن عدم كفاية تنظيف حفرة البئر.

الكلمات المفتاحية:تنظيف البئر,الخصائص االنسيابية,مائع الحف

GENERAL INTRODUCTION

The constantly circulating mud cools the forage tool and helps attack the rock by pressure injection and cleans the hole by removing the pieces of crushed rock.

It is also essential for maintaining the hole, to prevent its collapse ,Fodder mud is generally water-based to which numerous substances have been added products Firstly solid particles (often clays) used to increase the density of the gem, following the various chemicals used for their properties adapted to the nature of the terrain crossed for the stabilizer.

The fodder mud can undergo several alterations during penetration into the hole (the contamination). These problems are due to interactions with clay rocks contained in the different formations crossed. This most often leads to a hydration of these clays and consequently their swelling followed by their dispersion.

This problem has been solved so far thanks to the use of fodder fluids based on of oil. But faced with the problem of leaking used oil and the risk of polluting environment, we use water-based forage fluids.

This work is subdivided into two parts:

- a theoretical part:
  in which I mentioned generalities about oil drilling, the fodder sludge and their rheological and physical characteristics and parameters of fodder
- a practical part:
  in which I presented my work on site, the results obtained and their interpretations.

Chapter I : Introduction To Drilling Fluid

Introduction:

Drilling fluids are fluids used in the drilling of subsurface well by combining density with any additional pressure acting on the fluid column (annular or surface imposed), they offer main well Control of subsurface pressures [1].

Drill cuttings are typically removed from the wellbore by circulating them down the drill string, out the bit, and back up the annulus to the surface. Drilling fluids are known by a variety of industry acronyms and slang terms, but the most common one is "mud" or "drilling mud," which will be used interchangeably in this chapter [2].

1 definition of drilling fluids:

Drilling mud is a system composed of different liquid constituents (water, oil) and/or gaseous (air or natural gas) containing other mineral additives in suspension and organic (clay, polymers, surfactants, spoil, cement, etc.), In 1979 the American Petroleum Institute (IAP) defined drilling fluid as a fluid in continuous circulation throughout the duration of drilling, both in the borehole and on the surface [3].

The fluid is prepared in sludge tanks, it is injected inside the rods up to the tool from where it rises in the annular, loaded with spoil formed at the working face, At the exit of well, it undergoes different treatments, sieving, dilution, addition of products, in order to eliminate the excavated material trans-ported and readjust its physicochemical characteristics to their values initials, it is then reused [4].

2 Types of Circulation of drilling fluids:

There are two primary types of drilling fluid circulations: reverse circulation and conventional circulation.

2.1 Conventional Circulation:

The most popular kind of drilling fluid circulation is this one. Drilling fluid is injected down the drill pipe, leaves through jets in the drill bit, and then returns up the well-bore outside the drill pipe in a normal circulation system. Rock cuttings are transported to the surface by the drilling fluid, where they are removed and disposed of [5].

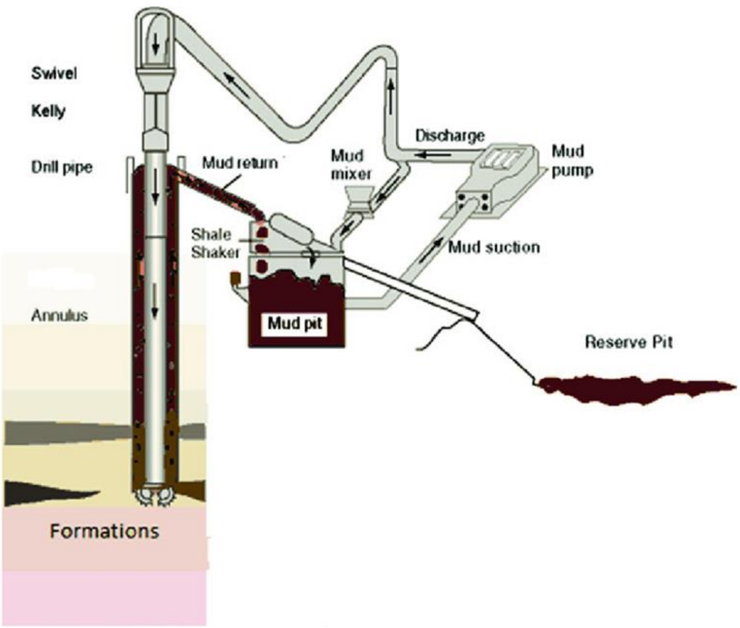


Figure 1: Drilling fluid circulating system

2.2 Reverse Circulation:

Drilling fluid is pushed down the wellbore outside the drill pipe and out via the drill bit in reverse circulation. After that, the rock shavings and drilling fluid return to the drill pipe. In certain circumstances, such as when drilling in extremely loose strata or attempting to recover lost circulation materials, reverse circulation is employed [5].

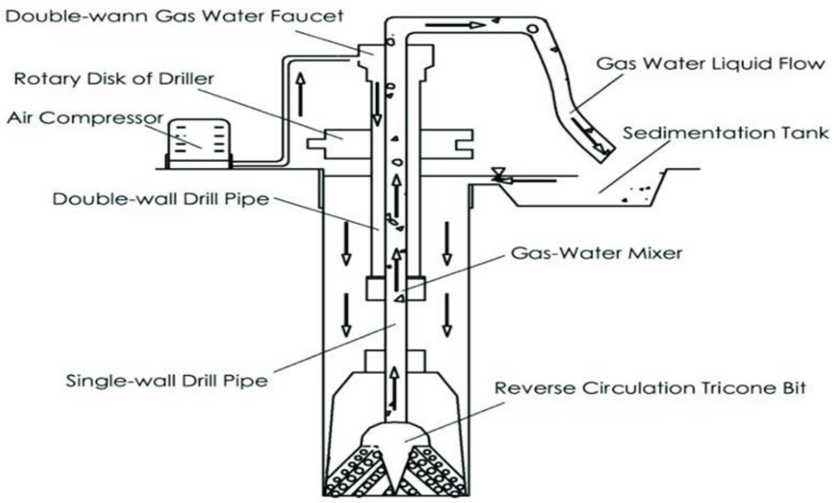


Figure 2: Reverse Circulation Drilling Technology Principal Diagram

3 The Function of Drilling Fluids:

Drilling fluids, sometimes referred to as drilling mud, are essential to the effective drilling of wells. They carry out a number of vital tasks during the drilling operation, including:

- **Wellbore Control:** In order to offset the pressure of formation fluids attempting to enter the wellbore, drilling fluid applies hydrostatic pressure. This is the main purpose, which ensures well control and safety by stopping the uncontrolled flow of gas, oil, or water into the wellbore.
- **Cutting Transport:** The drilling fluid moves the rock shavings that the drill makes towards the surface. This maintains the wellbore clean and facilitates effective drilling.
- **Wellbore Stability**: As a result of interactions with the formation walls, drilling fluid coats the wellbore and prevents it from collapsing. When digging through weak or unconsolidated rocks, this is very important.
- **Cooling and Lubrication:** Drilling creates a lot of friction, and the drill bit and other downhole instruments are kept cool by the circulating fluid. It also lubricates the drill string, which lessens wear and friction.
- **Formation Protection:** The appropriate composition of drilling fluid can reduce harm to the formations that are being drilled through. This is necessary to guarantee that, after it is finished, gas and oil flow into the wellbore properly.
- **Downhole Information:** A wealth of knowledge about the formations being drilled through can be gleaned from the characteristics of the drilling fluid that is returning to the surface. This enables engineers to modify the fluid characteristics and drilling parameters as necessary.
- **Environmental Considerations:** In order to obtain the required qualities, drilling fluids are produced with a variety of additives. Choosing and using these chemicals correctly reduces the negative effects drilling operations have on the environment [7].

4 The Different Types of Drilling Fluids:

There are three main types of drilling fluids used in oil and gas well drilling:

- **Water-Based Fluids (WBFs).**
- **Oil-Based Fluids (OBFs).**
- **Pneumatic Drilling Fluids.**

4.1 Water-Based Fluids (WBFs):

Water-based fluids use water (fresh water, seawater, brine, etc.) as the base fluid, with various additives like clays, polymers, and weighting agents mixed in [8].

They are the most widely used type of drilling fluid, accounting for about 80% of all drilling operations.

Figure 3 : Water-Based Mud

They are tertiated (preferred) due to their lower cost and environmental impact compared to other options like oil-based fluids (OBFs).

Composition:

- **Base Fluid:** This can be fresh water, seawater, brine (saltwater), or a specialized brine solution. The type of base fluid used depends on the specific well conditions.
- **Additives**: A variety of additives are used to enhance the properties of WBFs for different drilling needs. Some common additives include.
- **Viscosity modifiers**: Thicken the fluid to control pressure and prevent formation collapse.
- **Shale inhibitors**: Prevent clays in the rock from hydrating and swelling, which can cause problems with wellbore stability.
- **Lubricants:** Reduce friction between the drill bit and the formation, improving drilling efficiency.
- **Lost circulation materials:** Help prevent fluid loss into the formation.

Use:

WBFs are a versatile drilling fluid and can be formulated for a wide range of well conditions. They are generally preferred when:

- Drilling shallower wells.
- Drilling through less sensitive formations.
- Cost is a major consideration.

These fluids are made up of three distinct phases [9]:

- **Liquid phase**: it represents water, this water can be soft or salty, the salinity of drilling fluids depends on the salinity of the water manufacturing.

- **Colloidal phase**: this phase is essentially made up of clays, the latter have two functions, one of which is primary which represents the viscosity offered by the clay, and the other is secondary such as the reduction of filtrate.
- **Solid phase**: solids added to the drilling fluid such as barite BaSO4 (known as Barite or barite) but also sand, limestone and dolomites are bodies insoluble in water, they only act through the effect massive.

4.1.1 Advantages:

- Lower cost compared to other fluids.
- Readily available water source in most places.
- Environmentally friendly.

4.1.2 Disadvantages:

- Limited wellbore stability in reactive shales.
- Higher risk of formation damage.
- Not suitable for high-temperature wells.

4.2 Oil-Based Fluids (OBFs):

Oil-based fluids use oil (either natural or synthetic) as the base fluid, along with brine and solids additives [10].

Oil-Based Fluids (OBFs) are a type of drilling fluid used in oil and gas extraction, they differ from other drilling fluids because oil, rather than water, is the main component.

Figure 4 : Oil- Based Mud

They are composed of:

- **Base oil:** This is the main component, typically mineral oil but can also be synthetic
- **Water droplets:** OBFs are emulsions, meaning tiny water droplets are suspended throughout the oil.
- **Additives:** Various substances are added to OBFs to improve their performance. These can include lubricants, emulsifiers, and formation stabilizers.

Use:

OBFs offer several advantages over water-based fluids, such as better lubrication and borehole stability in certain formations, however they are also more expensive and environmentally hazardous.

Due to these factors, OBFs are typically used in specific situations, such as:

- Drilling in deep wells.
- Drilling through formations that are sensitive to water.
- When encountering high-pressure zones.

4.2.1 Advantages

- Excellent wellbore stability in reactive shales.
- Superior lubrication and cooling properties.
- Better performance in high-temperature well.

4.2.2 Disadvantages:

- Higher cost compared to WBFs.
- More complex to handle and dispose of due to environmental regulations.
- Health and safety concerns associated with oil handling.

4.3 Pneumatic Drilling Fluids:

Pneumatic drilling fluids use air, mist, foam, or gas as the circulating fluid.

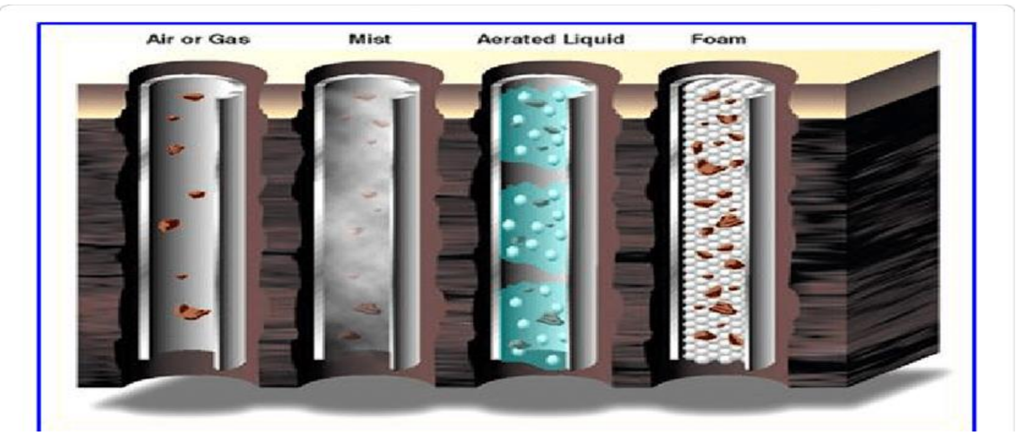


Figure 5: Compressible drilling fluids technologies (Weatherford,2002)

Pneumatic drilling fluids, also known as gas-based mud or air-based mud, are a type of drilling fluid used in special circumstances where conventional drilling fluids like water-based or oil-based fluids are not ideal. They are typically used in formations with low water content and when there is a risk of losing circulation of the drilling fluid into the formation [11].

There are three main types of pneumatic drilling fluids:

- **Air or Gas Only**: This is the simplest type of pneumatic drilling fluid and consists solely of compressed air or gas, such as nitrogen, natural gas, or carbon dioxide.

It is most effective in short sections of very permeable formations with low formation pressure.

- **Aerated Fluid**: An aerated fluid is a mixture of air or gas and a liquid, typically water or a brine solution.

The amount of air or gas in the mixture can be varied to achieve the desired properties. Aerated fluids are useful for removing cuttings from the wellbore and cooling the drill bit.

- **Foam**: Foam drilling fluids are a type of aerated fluid that contains a foaming agent, which creates a stable foam with a high gas-to-liquid ratio, Foam drilling fluids are effective for lifting cuttings from the wellbore and can be used in formations with higher formation pressures than air or gas alone.

4.3.1 Advantages:

- Rapid penetration rates in certain formations.
- Reduced risk of formation damage.
- Minimal wellbore cleanup required.

4.3.2 Disadvantages:

- Limited application due to formation restrictions.
- Difficulty in controlling wellbore pressure.
- Potential safety hazards associated with using air or gas under pressure.

5 Different types of drilling fluids additives & products:

5.1 Density Controllers (Weighting Agents):

These are crucial for maintaining wellbore pressure and preventing formation fluids from entering [12]. Here's a breakdown of some common types:

- **Barite ($BaSO_4$):** The most widely used weighting agent due to its high density, low cost, and inertness. However, it can be challenging to grind and disperse efficiently.
- **Hematite (Fe_2O_3):** Offers high density and can be a good alternative to barite in some situations. It's denser than barite but can be more abrasive on drilling equipment.
- **Ilmenite ($FeTiO_3$):** Denser than barite and hematite, but more expensive and less readily available. Can be beneficial in deep wells requiring high pressure control.
- **Calcium Carbonate ($CaCO_3$):** A natural, eco-friendly option with lower density than the above. Useful in shallower wells or when formation sensitivity is a concern.
- **Iron Powder (Fe):** High density but highly reactive and can cause corrosion problems. Requires careful handling and specific additives to mitigate these issues.

Factors to Consider When Choosing a Density Controller:

- **Desired density**: The required density will depend on the wellbore pressure and formation characteristics.
- **Cost:** Barite is generally the most cost-effective option, but other factors like disposal costs for environmentally friendly alternatives may need to be considered.
- **Formation sensitivity**: Some formations are sensitive to certain weighting agents. For example, calcium carbonate is preferred in water-sensitive formations.
- **Drilling depth**: Denser options like ilmenite might be necessary for deep wells with high pressure requirements.

5.2 Viscosifiers:

These additives control the thickness of the drilling fluid, impacting its ability to suspend cuttings, control pressure, and lubricate the drill bit [13]. Here are some common types:

- **Clays (Bentonite):** A natural and cost-effective viscosifier that hydrates in water to form a gel structure. However, bentonite can be sensitive to high temperatures and salinity.
- **Polymers:** Synthetic or semi-synthetic polymers offer good viscosity control even at high temperatures and salinity. They can be more expensive than clays but offer better performance in challenging conditions.
- **Xanthan Gum:** A biopolymer derived from corn sugar, effective for increasing viscosity at low concentrations. It's a good option for environmentally sensitive applications.

Factors to Consider When Choosing a Viscosifier:

- **Desired viscosity**: The required viscosity depends on wellbore conditions, hole size, and type of drilling fluid used.
- **Temperature stability**: Some viscosifiers, like bentonite, lose effectiveness at high temperatures. Choose a viscosifier suitable for the expected downhole temperature.
- **Shear stability**: The drilling process can subject the fluid to shear forces. Select a viscosifier that maintains its viscosity under these conditions.

5.3 Fluid-loss control additives:

These are materials that are added to the drilling fluid to reduce the amount of fluid that filters into the formation. This is important because excessive fluid loss can lead to a number of problems, such as wellbore instability, differential sticking, and lost circulation. Some common fluid-loss control additives include bentonite clay, starch, and sized calcium carbonate [14].

This is crucial because excessive fluid loss can lead to several problems, including:

Wellbore instability: When drilling fluids leak into the formation, it can weaken the rock and cause the wellbore to collapse.

Differential sticking: If the drilling fluid invades the formation around the drill pipe, it can create a situation where the pipe becomes stuck in the hole.

Lost circulation: This occurs when drilling fluids leak into highly permeable zones in the formation, and there's not enough fluid left to circulate through the wellbore.

the most common types of fluid-loss control additives used in drilling fluids:

- **Bentonite Clay:**

  The workhorse of fluid-loss control, bentonite clay is a natural clay material composed primarily of sodium montmorillonite. When hydrated, the microscopic plate-like particles of bentonite form a thin, dense layer on the wellbore wall called a filter cake. This filter cake helps to prevent the drilling fluid from leaking into the formation, which can cause a number of problems, including wellbore instability and formation damage [15].

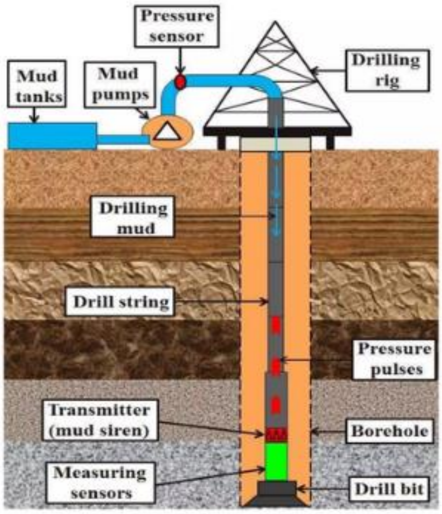


Figure 6: Drilling Mud Cycle

- **Polymers:**

  Various synthetic and natural polymers are used as fluid-loss control additives. These polymers act by increasing the viscosity of the drilling fluid, which helps to reduce the rate at which fluid can leak into the formation. Common examples of polymers used for fluid-loss control include xanthan gum, carboxymethylcellulose (CMC), and polyacrylamide (PAM)[14] .

Figure 7: Polymers (Xanathan gum)

- **Gilsonite:**

  A naturally occurring asphalt material, gilsonite is a cost-effective and environmentally friendly alternative to some synthetic polymers. Gilsonite particles form a low-permeability filter cake on the wellbore wall, helping to control fluid loss [15].

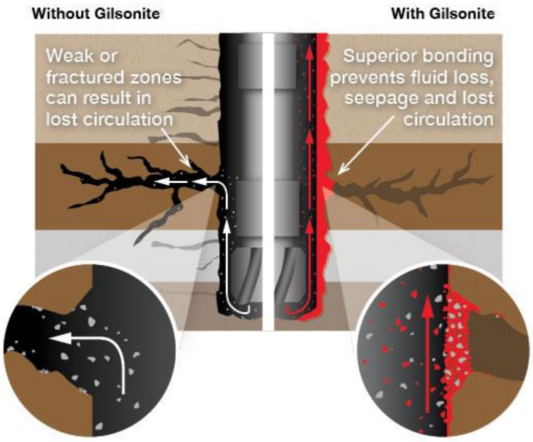


Figure 8: Gilsonite Work Scheme

Filtration Reducers:

Its purpose is to Maintain a smooth flow of drilling fluid by preventing drilled solids from clumping together.

Types as Lignosulfonates (most common): Organic dispersants that coat drilled solids, keeping them separate.

Figure 9: Lignosulfonates Powder

Benefits:

- **Improved hole cleaning**: Separated solids flow more easily, preventing blockages.
- **Reduced friction**: Less friction means lower pump pressure requirements.
- **Minimized formation damage**: Solids don't plug pores in the rock.
- **Enhanced wellbore stability:** Reduced risk of collapse due to clogged fluid.

Emulsifiers and Wetting Agents:

Emulsifiers and wetting agents are essential additives in oil-based drilling fluids, ensuring a smooth and efficient drilling process [16]. Here's a closer look at their purpose, types, and benefits

Purpose:

- **Emulsification:**

Emulsifiers help create and stabilize emulsions, which are mixtures of two immiscible liquids, like oil and water, in oil-based drilling fluids. They prevent the oil and water from separating, ensuring a uniform and stable drilling fluid.

Common Additives:

- **Fatty Acids:** These organic compounds are the most common emulsifiers used in oil-based drilling fluids. They act by reducing the interfacial tension between oil and water, allowing for the formation of stable emulsions.
- **Imidazolines:** Imidazolines are particularly beneficial in high-temperature and high-pressure drilling environments due to their excellent thermal stability.
- **Sorbitan Esters:** Sorbitan esters offer good emulsification properties and can also act as wetting agents, improving the interaction between the drilling fluid and drilled cuttings

- **Amphoteric Surfactants:** amphoteric surfactants can also offer improved tolerance to variations in salinity and pH levels, which can be encountered in different drilling environments.

Wetting agents:

also known as surfactants, are a type of additive used in various industrial processes, including oil drilling. Their primary function is to **reduce the surface tension of liquids**, allowing them to spread and penetrate more easily [17].

In oil-based drilling fluids, wetting agents play a crucial role by:

- **Enhancing Contact with Drill Cuttings**: Wetting agents improve the interaction between the drilling fluid and drilled rock fragments (cuttings). This allows the fluid to adhere more effectively to the cuttings, facilitating their removal from the wellbore and preventing them from sticking to the drill string or wellbore walls.
- **Promoting Emulsion Stability**: In some cases, wetting agents can also act synergistically with emulsification additives. They can help stabilize the emulsion formed by oil and water in oil-based drilling fluids, further enhancing the overall performance of the fluid.

Benefits of Using Wetting Agents:

- **Improved Hole Cleaning**: Effective wetting agents promote better adhesion of the drilling fluid to cuttings, leading to more efficient removal and reduced risk of blockages in the wellbore.
- **Enhanced Lubrication**: Wetting agents can improve the lubricating properties of the drilling fluid, especially in oil-based fluids, which are inherently more lubricating than water-based fluids. This helps reduce friction between the drill string and the wellbore wall, minimizing torque and wear on drill string components.

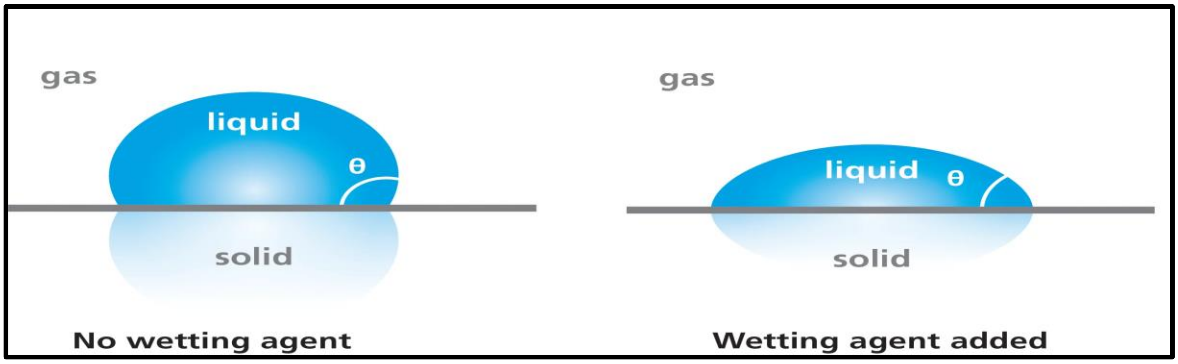


Figure 10: PH control Agent Working Schematic on a droplet

pH control agents are additives used in oil drilling fluids to maintain the proper pH level

[18].

The pH of the drilling fluid is crucial for several reasons including:

- **Clay behavior:**

  The performance of clays in the drilling fluid is highly dependent on pH. At the right pH, clays will properly hydrate and form a good gel structure which is essential for carrying cuttings and sealing the wellbore. If the pH is too high or too low, the clays can flocculate (clump together) which can cause problems with hole stability and filtration [19].

Figure 11: Close up picture of Clays in Drilling Mud

- **Polymer performance:** Many polymers used in drilling fluids are also pH sensitive. At the proper pH, they will efficiently hydrate and provide the desired rheological properties (thickness and flow behavior) to the drilling fluid.
- **Corrosion control:** The pH of the drilling fluid can also affect the rate of corrosion of downhole tubulars. By maintaining a slightly alkaline pH, the corrosion rate can be minimized.

Types of pH control agents used in oil drilling fluids:

- Alkaline agents: These are used to raise the pH of the drilling fluid. Common examples include sodium hydroxide (caustic soda), soda ash (sodium carbonate), and lime (calcium hydroxide).
- Acidic agents: These are used to lower the pH of the drilling fluid. Common examples include hydrochloric acid and organic acids such as citric acid or acetic acid.

The selection of the appropriate pH control agent will depend on the specific requirements of the drilling fluid and the formation being drilled.

common types of used agents:

- **Sodium Hydroxide (Caustic Soda).**

Figure 12: Sodium Hydroxide

A highly effective alkaline agent used to increase drilling fluid pH. It's potent, so it should be handled with care.

- **Soda Ash (Sodium Carbonate):**

Figure 13: Sodium Ashe

A milder alkaline agent compared to sodium hydroxide. It's frequently used to control pH in drilling fluids because it's less corrosive.

- **Lime (Calcium Hydroxide):**

A cost-effective alkaline agent that can also help to inhibit clay swelling.

Acidic Agents are used to lower the pH of drilling fluids. Here are some common types:

A strong acid used to reduce pH quickly. Due to its corrosive nature, it requires careful handling.

- **Organic Acids (Citric Acid or Acetic Acid):**

Milder organic acids that can be used to lower pH while minimizing corrosion concerns compared to hydrochloric acid.

Mud Treatment circuit:

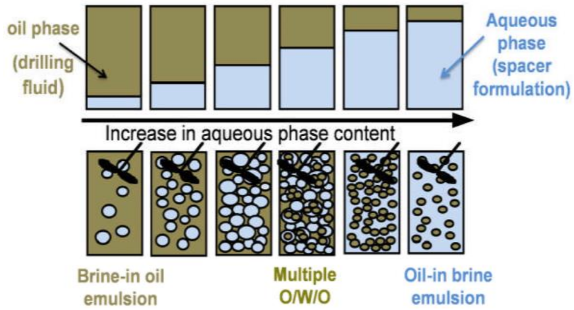


Figure 14: Mud Treatment Schematic**.**

Flow Path:

Drilling fluid containing cuttings exits the wellbore through the suction line.

The fluid first passes through the shale shakers (in series). Large cuttings are separated and disposed of.

The fluid then enters the desander, where sand particles are removed Next, the fluid flows through the desilter for further removal of finer silt particles. The desilted fluid may then be directed to a centrifuge (optional) for even more advanced solids separation.

The (partially) cleaned drilling fluid flows into the mud tanks. Heavier solids settle at the bottom of the tanks, while the lighter fluid remains on top. Mud from the top of the tanks is drawn by the mud pumps and sent to the mud mixing unit, where fresh components and additives are blended to maintain the desired fluid properties. The treated mud is then pumped back down the wellbore through the discharge line. Optionally, a skimmer can be used on the surface of the mud tanks to remove any oil contamination. A degasser (optional) can be placed before the mud mixing unit to remove entrained gas bubbles.

Mechanical treatment of drilling fluids is a crucial part of maintaining their performance during the drilling process. These techniques address various issues like removing solids, controlling particle size, and managing aeration [20]

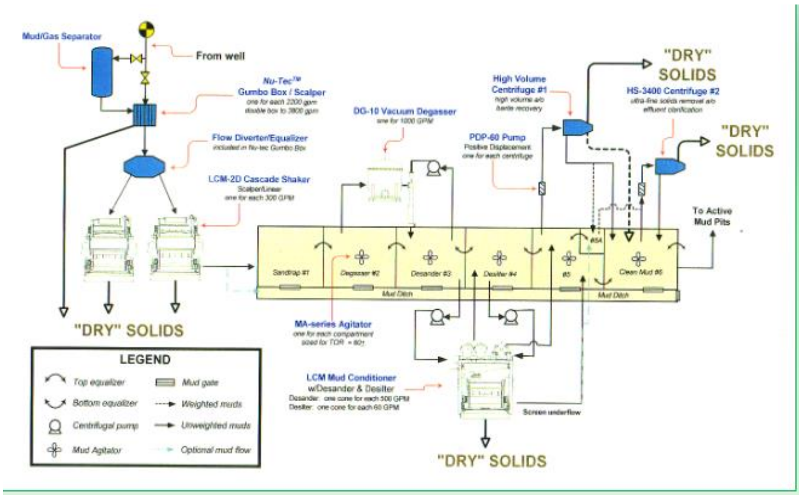


Figure 15: Mechanical treatment of Drilling Mud

key methods of mechanical treatment and their functionalities:

5.4 Solid Control Equipment:

- **Shale Shakers:**

These workhorses are essentially vibrating screens positioned along the drilling fluid's return line; they separate large cuttings generated by the drilling bit from the fluid. Shale shakers come in various configurations with different screen sizes and vibration patterns.

Figure 16: Shale Shakers Of Aipu

Shale shakers are the first line of defense in removing unwanted solids that could hinder drilling efficiency

The size of the screen mesh determines the maximum size of particles allowed to pass through

A common combination of mesh sizes used is 30-mesh screen on the upper deck and 80-mesh screen on the lower deck, as the working life of very fine mesh screens is quite short.

Drilled solids down to 177 microns are removed by 80-mesh screens, and 840-micron size particles by 20- -mesh screens.

- **Desanders and Desilters:**

These are specialized hydro-cyclones that utilize centrifugal force to separate sand (desander) or silt (desilter) from the drilling fluid. The fluid is spun at high velocity, flinging the denser sand or silt particles outwards where they can be collected for disposal.

Figure 17: Desilters & Desanders

Common oil fields desanders are 12" to 6" I.D. hydrocyclones. They process fluid from immediately below the sand trap, not from the sand trap. A typical desanding set up consists of enough cones to process 125% to 150% of the flowline gpm.

Most desilters currently in use consist of banks of 4" I.D. hydrocyclones. This equipment processes fluid from below the desander.

Enough cones are used to process 150% of the circulating rate.

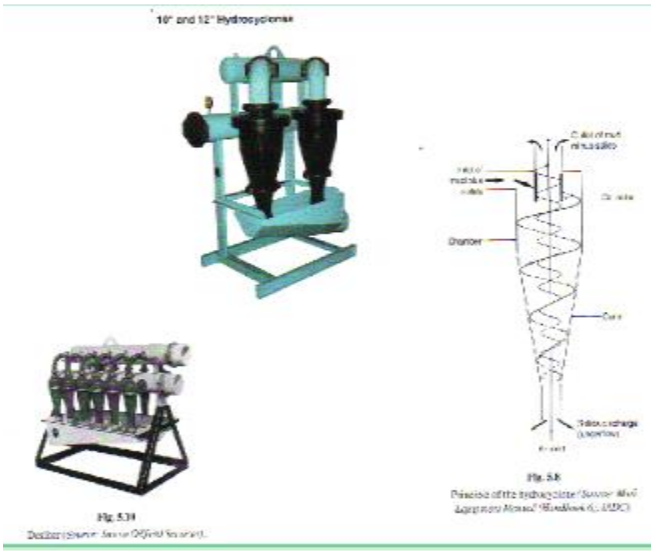


Figure 18: Hydrocyclones schematic

- **Centrifuges:**

These are more advanced separators that can remove a wider range of solids, including drilled rock cuttings and weighting material. By spinning the fluid at very high speeds, even finer particles can be separated based on their density. Centrifuges are often used for recycling drilling fluids or for specialized applications requiring very clean fluids [20].

Figure 19: Centrifuges Pumps

The decanting centrifuge is used to recover barite and remove fine solids from the drilling fluid.

The solids removed with a centrifuge are the very fine (below 4.5 to 6 microns) particles which have a greater effect on rheology.

The decanting centrifuge uses a rotating bowl to create high centrifugal force to affect the separation of coarse and fine particles. A conveyor screw rotates at a slower speed to move the coarse solids to the underflow port.

- **Degassers:**

These units remove entrained gas bubbles from the drilling fluid. The presence of gas can affect the density and rheological properties (flow behavior) of the fluid. Degassers typically use a combination of pressure reduction and agitation to promote gas release from the fluid [21].

Figure 20: Degassers

This is a schematic of how its working:

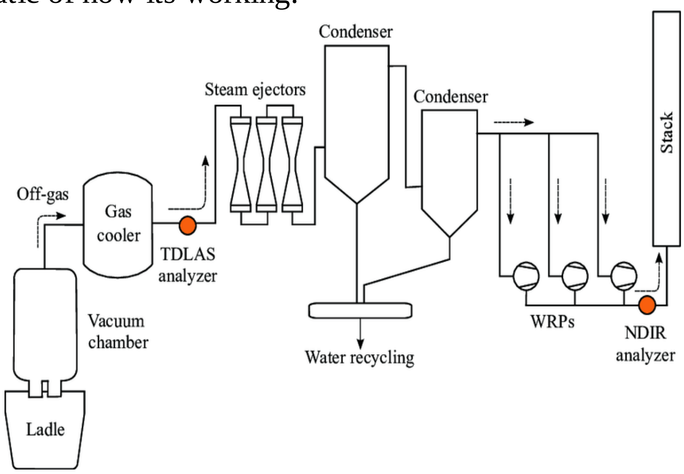


Figure 21: Degasser working schematics

- **Skimmer:**

refers to a device specifically designed to remove oil or other light floating materials from the surface of the drilling mud tank these drilling fluid skimmers are not involved in removing solid debris.

skimmers function in drilling operations:

Drilling fluids can become contaminated with oil during the drilling process. This oil can originate from various sources, such as the formation itself, lubricants used downhole, or leaks from equipment. The presence of oil can negatively impact the properties of the drilling fluid, hindering its performance.

Skimmers help remove this oil layer from the mud tank surface, maintaining the integrity of the drilling fluid.

Drilling fluid skimmers can vary in design, but some common features include:

- **loating Arm:** This arm rests on the surface of the drilling fluid and skims off the floating oil layer.
- **Belt System:** Some skimmers utilize a continuous belt that rotates through the oil layer, collecting oil and carrying it to a disposal container.
- **Weir Overflow:** This design allows the clean drilling fluid to flow under a weir (a barrier) while the oil layer accumulates on top and is skimmed off.

Benefits:

Using skimmers in drilling operations offers several advantages:

- **Maintains drilling fluid properties:** By removing oil contamination, skimmers help ensure the drilling fluid maintains its desired rheological properties (flow behavior) and lubricity.
- **Reduces environmental impact:** Oil contamination in drilling fluids can pose an environmental risk. Skimmers help prevent oil from being discharged with the drilling fluid cuttings.
- **Cost savings:** By extending the lifespan of the drilling fluid by removing contaminants, skimmers can contribute to cost savings by reducing the need for frequent mud changes [22].

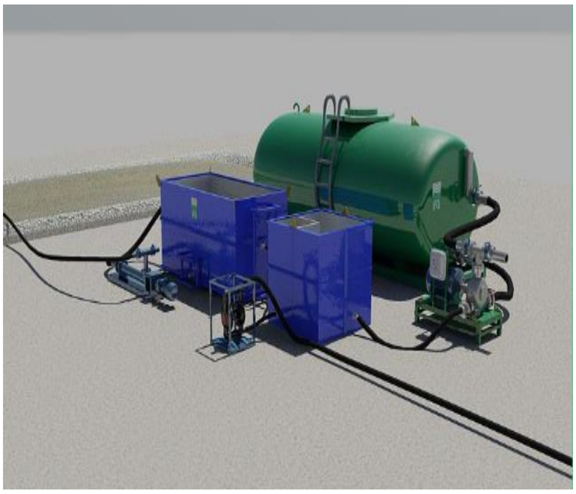


Figure 22: Skimmer

skimmers play a crucial role in maintaining the quality and performance of drilling fluids during oil and gas well construction.

Mud treatment performances:

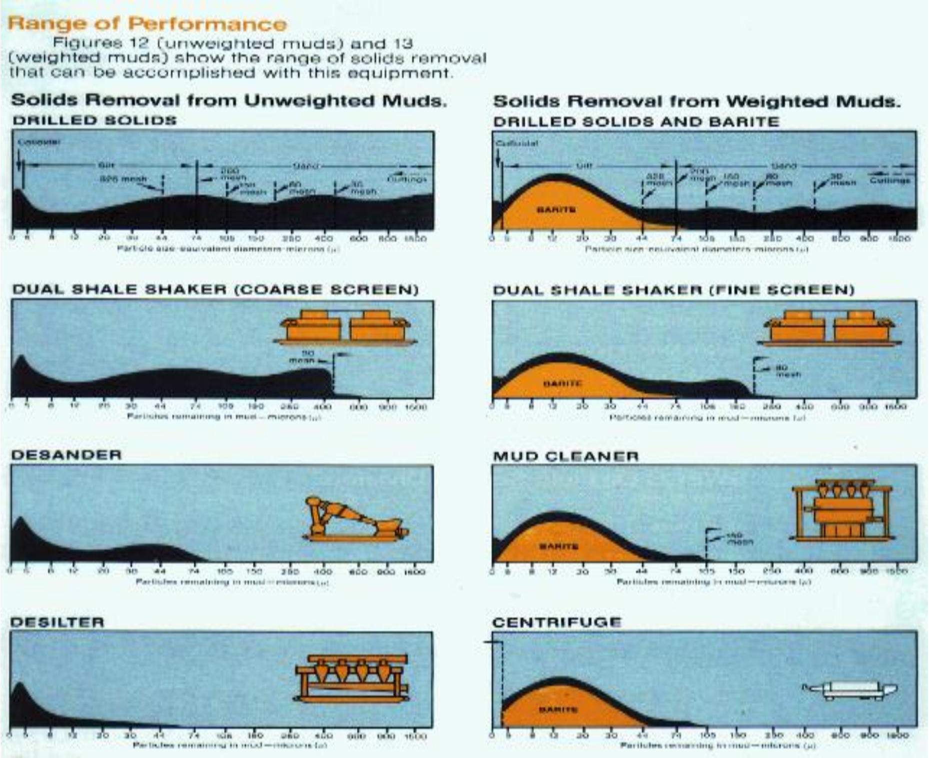


Figure 23: Mud Treatment Performances in drilled solids & barite for solids reomvals from Unweighted muds

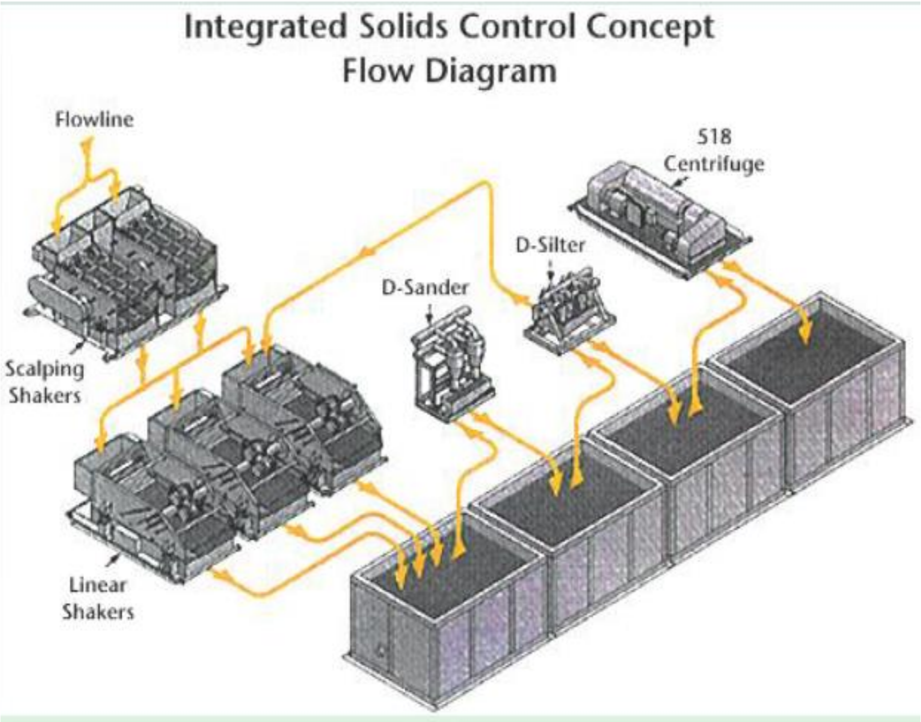


Figure 24: Integrated Solids Control Flow

Conclusion

In some cases, rigorous maintenance or monitoring of drilling mud may not be sufficient to ensure the success of a drilling operation and prevent unforeseen situations. The key to success lies in the criteria for selecting a mud system and a thorough study of the problems caused by the mud itself.

Chapter II : General information on drilling well cleaning

1 Introduction:

Effective hole cleaning, also known as wellbore cleaning, is an indispensable aspect of drilling operations. It involves the continuous removal of rock fragments and debris, collectively termed cuttings, generated during the drilling process. This seemingly simple task plays a critical role in maintaining wellbore integrity and ensuring the success of the entire drilling project.

2 The definition of Hole cleaning operation:

Cleaning a mud drilling well is an essential operation in the oil drilling process. When drilling mud is used to create hydrostatic pressure in the well in order to maintain the stability of the walls and to control the flow of fluids from the formation, it can also become contaminated with rock debris, loops, metal particles, cement residues or other contaminants. Cleaning the well by mud involves the use of various tools and techniques to remove these contaminants from the circulating mud. These tools may include agitators, shakers, hydrocyclones, centrifugal decanters, and other processing equipment. The aim is to maintain the quality of the mud by eliminating unwanted particles, which helps ensure efficient and safe drilling operations.

3 Factors affecting hole cleaning:

The capacity of a drilling fluid to carry debris from the bottom of the well to the surface is affected by several factors.

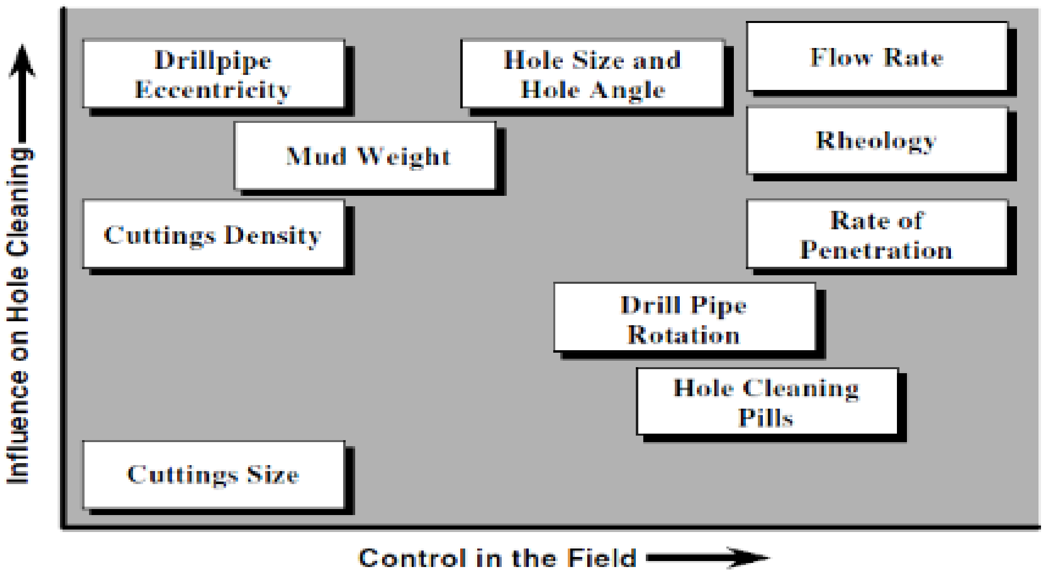


Figure 25: Key variables controlling cuttings transport **[23]**

Table 1: factors that influence the cleaning of the well

Mud Factors	Debris Factors	Wellbore Configuration and Operationnel Factors
Density	Density	Angle of inclination
Rheology	Size	Drill pipe Rotation
	Form	Rate of Penetration
	Debris Concentration	Drill pipe Eccentricity
		Flow Rate
		Depth
		Hole diameter/ interne diameter of the casing

The factors that influence the cleaning of the well are classified into two groups:

- Fixed factors.
- Adjustable factors.

3.1 Fixed factors:

These are factors that can be changed only slightly or not at all. Among other things we have:

3.1.1 Uncontrollable factors:

These factors are difficult to change due to the uncontrollable geometry of the well and the formations crossed, among them:

- **Drill Pipe Eccentricity:**

In directional drilling, a key parameter for wellbore integrity is drill pipe eccentricity. It describes how far off-centre the drill pipe is positioned within the wellbore. Imagine a pipe running through a cylinder; zero eccentricity signifies perfect centring, while a value closer to 100% indicates the pipe is nearly touching the wellbore wall. This seemingly minor misalignment can significantly impact factors like hole cleaning efficiency and casing wear, making it crucial to monitor and manage for a successful drilling operation.

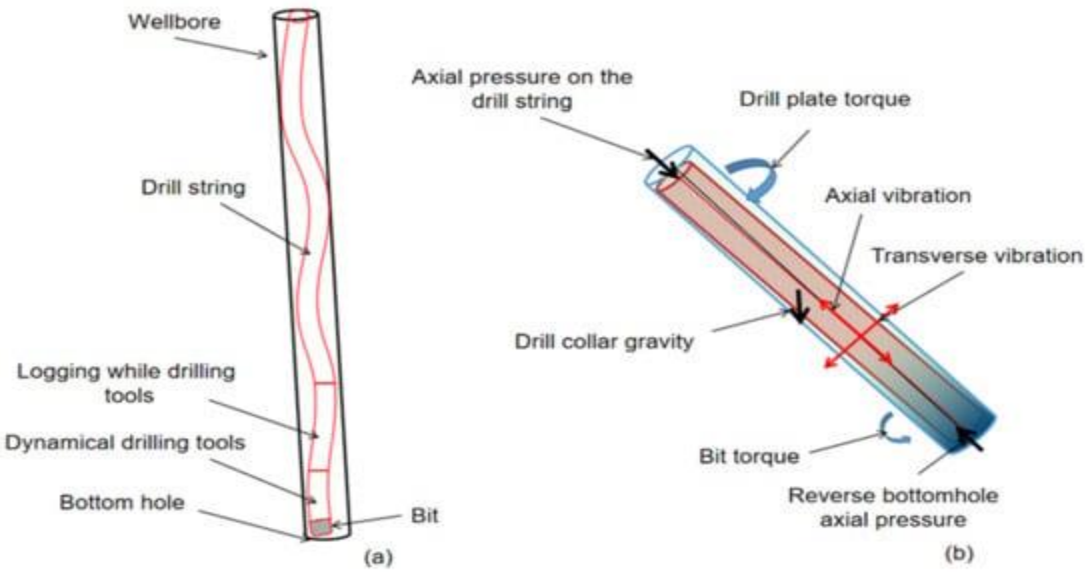


Figure 26: (a) Position and force of drill collars while drilling in the wellbore; (b) Schematic diagram of drill collar force **[24]**

- **Cutting/Particle size:**

Shape, size, and density of drill cuttings significantly impact their movement in flowing fluids. These characteristics, along with the properties of the circulating fluid, influence factors like terminal velocity (settling speed), drag force (resistance to movement), buoyant force (counteracting settling), and interactions between cuttings.

Sphericity, a measure of how closely a cutting resembles a sphere, helps quantify its shape. A perfectly round cutting has a sphericity of 1, while irregular shapes have lower values.

Figure 27: Sample of drill cuttings under a 10x microscope **[25]**

- **Cutting Density:**

Cutting density, also known as cuttings density or bulk density, is a critical parameter in drilling fluid characterization. It is defined as the ratio of the mass of the drill cuttings to the total volume occupied by the cuttings, including both the solid particles and the interstitial fluid or air spaces. The cutting density plays a crucial role in determining the behaviour of the cuttings transport process, as it influences the settling velocity and carrying capacity of the drilling fluid. Accurate measurement and control of cutting density are essential for optimizing drilling fluid properties, ensuring efficient hole cleaning, and mitigating potential problems such as barite sag, formation damage, and stuck pipe incidents.

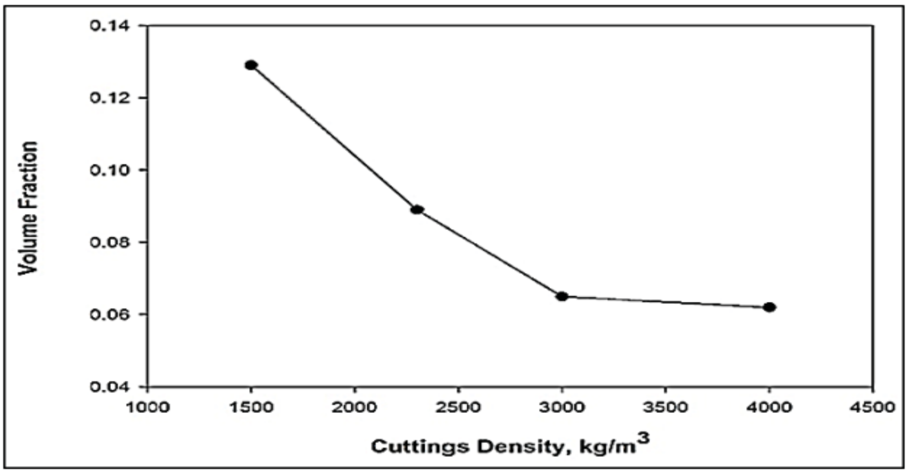


Figure 28: The effects of cuttings right density on the volume fraction in the released drilling fluid from the wellbore **[26]**

3.1.2 The controllable Factors:

- **Hole Angle:**

The hole angle, or wellbore inclination, is the angle between the wellbore trajectory and the vertical reference at a given depth. It determines the direction of the wellbore in directional and horizontal drilling. Accurately measuring and controlling the hole angle is critical for following the planned well path, targeting specific formations or reservoirs, optimizing drilling performance, maintaining borehole stability, and maximizing reservoir exposure. Directional drillers use techniques like rotary steerable systems and mud motors to adjust and maintain the planned hole angle.

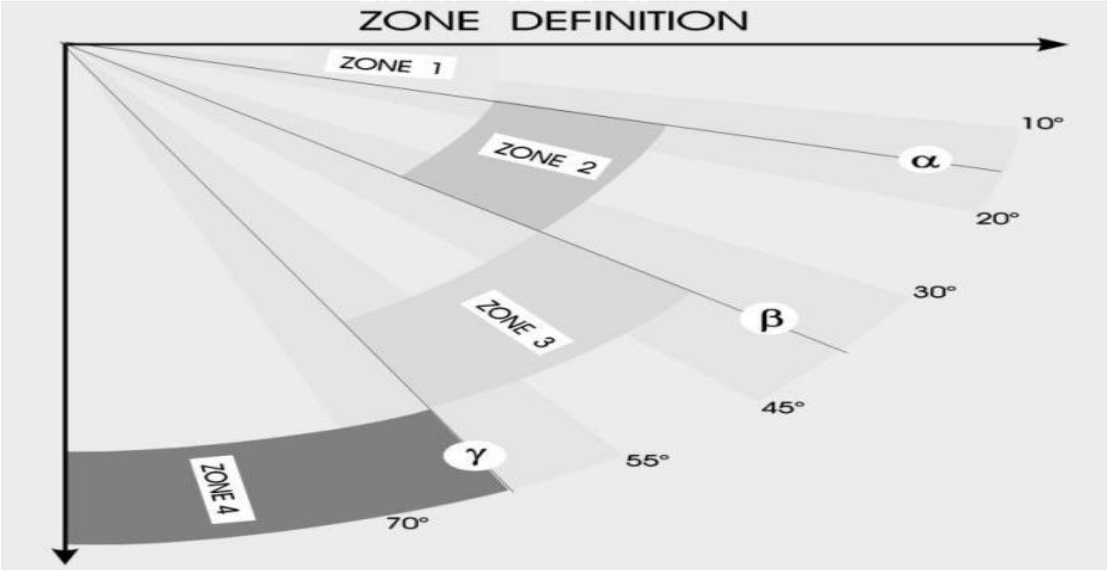


Figure 29: Critical inclination zone **[27]**

If possible, try to climb from β to γ as low as possible and as fast as possible in order to shorten the area where the cuttings bed tends to slide down.

➢ **Hole Diameter:**

The efficiency of moving the cuttings increases with increasing the diameter of the stems if the other parameters are constant, as the ring speed increases.

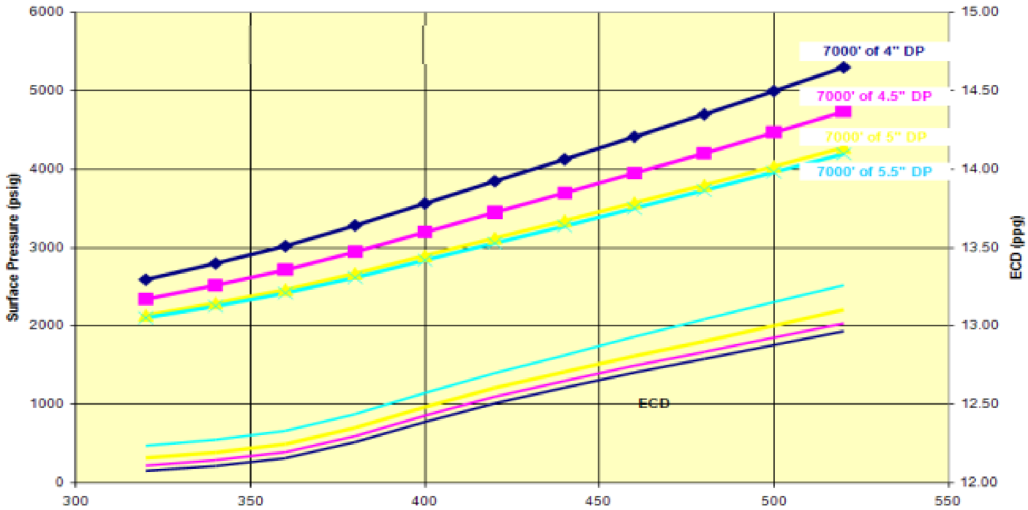


Figure 30: Influence of drill string diameter on the ECD

➢ **Mud Density:**

Density is one of the mud parameters affecting the transport of cuttings that can be modified if the circumstances allow it; The difference in densities (Δd = mud density - density cuttings)

is a determining parameter in the evacuation of cuttings: the larger the cutting, the more it increases, the greater the carrying capacity of the cuts [28].

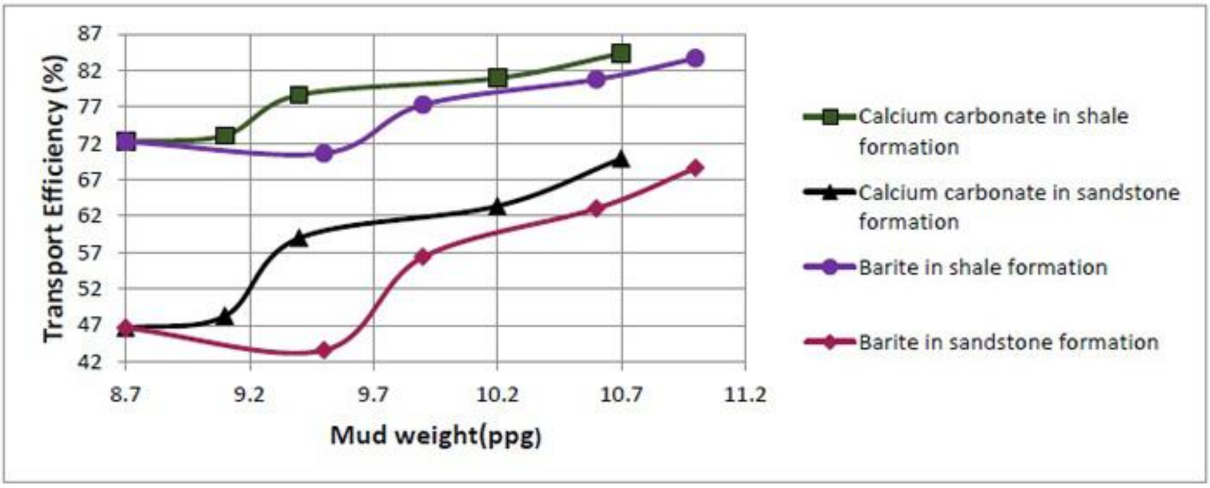


Figure 31: Effect of weighting materials on transport efficiency in shale and sandstone formations **[29]**

3.2 Adjustable factors:

➢ **Wells Flow Rate:**

In oil and gas well operations, well flow rate refers to the volume of fluid extracted from the well per unit of time. It's typically measured in barrels per day (BPD) or cubic meters per day (m^3/d). A well's flow rate is crucial for determining its production potential and planning for efficient extraction. Factors like reservoir pressure, formation characteristics, and wellbore size can influence the flow rate. Understanding and monitoring flow rate helps ensure optimal production and identify potential wellbore issues.

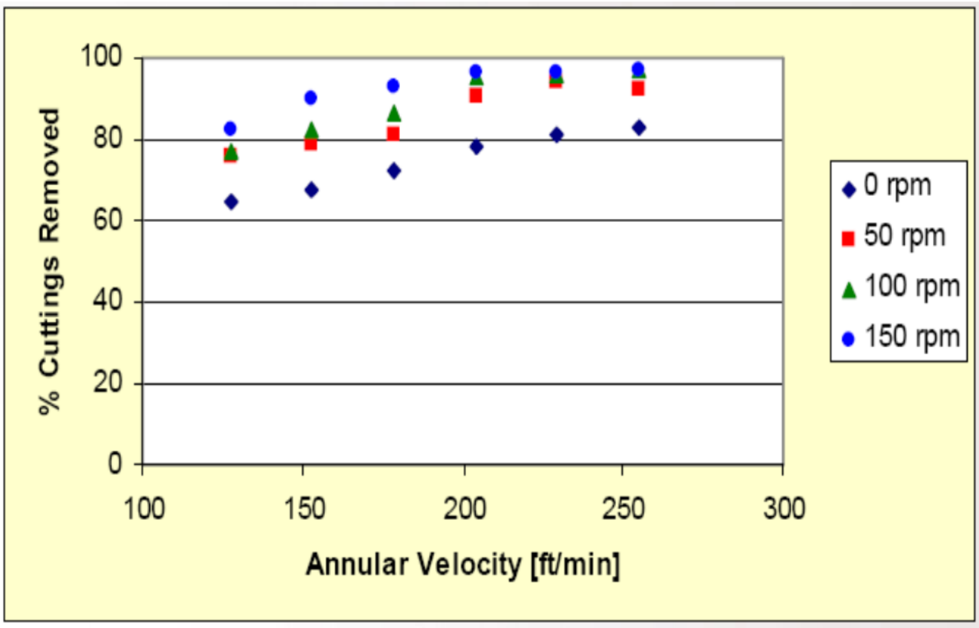


Figure 32: Influence of Annular Velocity on well cleaning **[30]**

➢ **Rate of penetration:**

Rate of penetration (ROP) is a critical parameter in drilling operations that measures the linear distance drilled per unit of time, typically expressed in feet per hour (ft/hr) or meters per hour (m/hr). It is influenced by various factors, including formation characteristics, bit design and condition, operating parameters (weight on bit, rotary speed, hydraulics), and drilling fluid properties. Optimizing ROP is crucial for maximizing drilling efficiency, reducing non-productive time, and minimizing overall well costs.

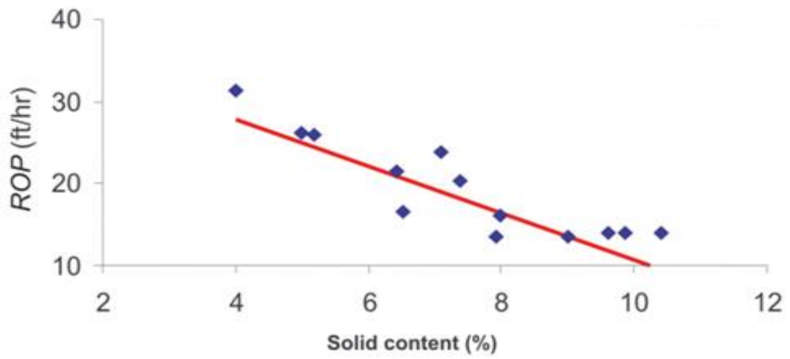


Figure 33: Effect of solid content on penetration rate **[9]**

➢ **Drill pipe Rotation:**

The rotation of drilling stems tends to make the flow turbulent around the BHA, which improves the cleaning capacity by raising the particles upwards this especially in the wells deviate, the graph if below shows the improvement of the capacity is cleaning with rotating the stems **[32]**.

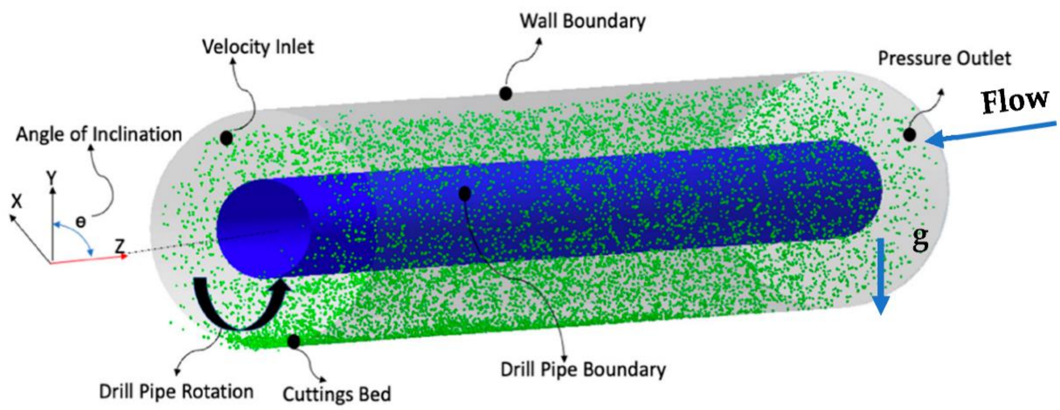


Figure 34: The effect of drill pipe rotation on cuttings transport in inclined wellbores **[33]**

➢ **The rheology of drilling mud:**

- **Yield Point:**

Deferent researchers have shown that Yield Value reduces Particle Velocity, and improves cleaning efficiency, if the figures below show the influence of Yield Values on well cleaning.

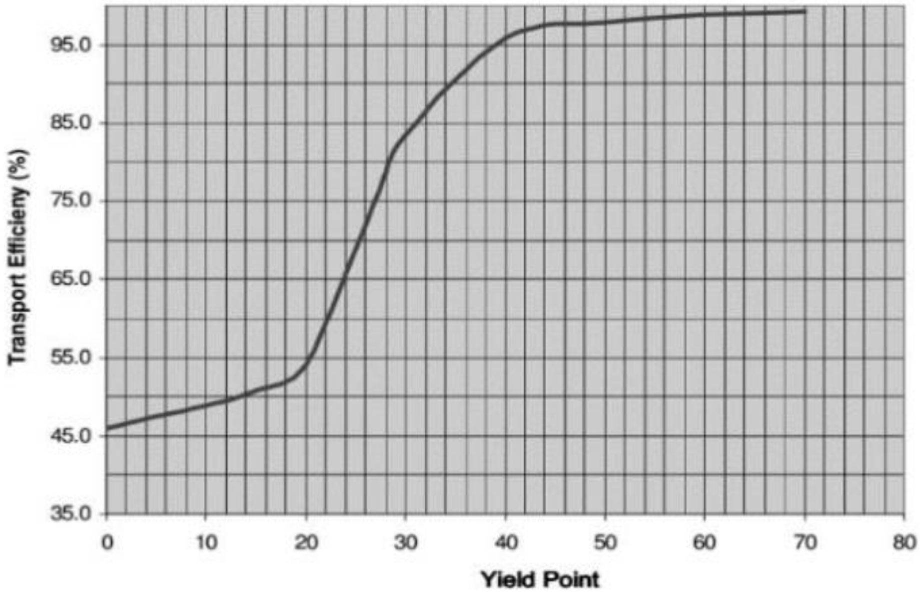


Figure 35: Effect of YP on cleaning efficiency **[34]**

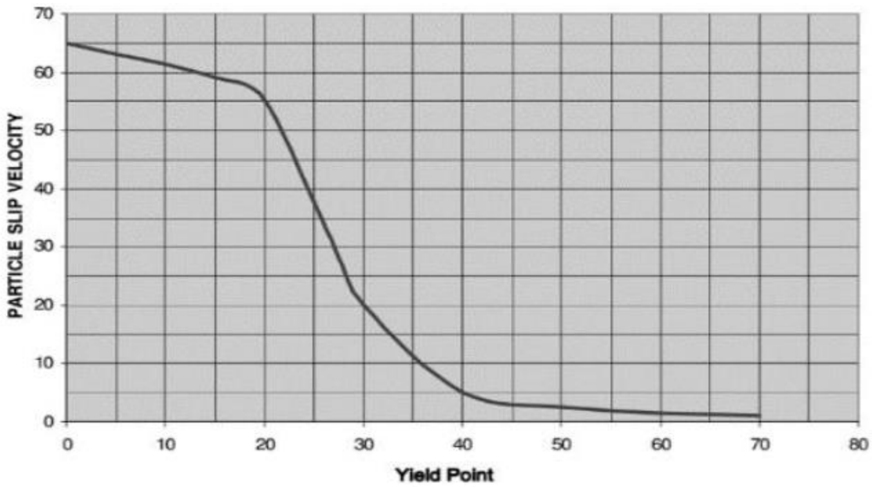


Figure 36: Effect of Yp on Particle Slip Velocity **[34]**

- **The YP/PV report:**

  An increase in the viscosity of the mud with high values of the "YP/PV" ratio, which means a decrease in the value of "n" which makes the flow profile flatten, will improve the cleaning this especially for luminary diets while for turbulent diets, the reduction in the viscosity of mud will help in the removal of cuttings [35].

- **The flow regime:**

  The laminar circuit is usually located in the ring space during drilling operations. This type of drainage is generally desirable in the anneal, as it does not lead to hole erosion, generates fairly small load losses and also for better efficiency of transporting the loads.

  The turbulent regime is the type of drain found inside the filling during drilling operations. The speed of the drilling mud must be very high to obtain it, this results in heavy loading losses. This type of leakage is undesirable in the ring space due to its tendency to cause hole erosion and a higher equivalent "ECD" flow density.

As for the drainage regime at the outlet of the drilling tool, it is preferable to be turbulent for better cleaning the tool and to avoid its crushing.

Experiments have shown that the laminar regimen gives better results for vertical to slightly deviated wells, while the turbulent regimen is better for diverted wells [36].

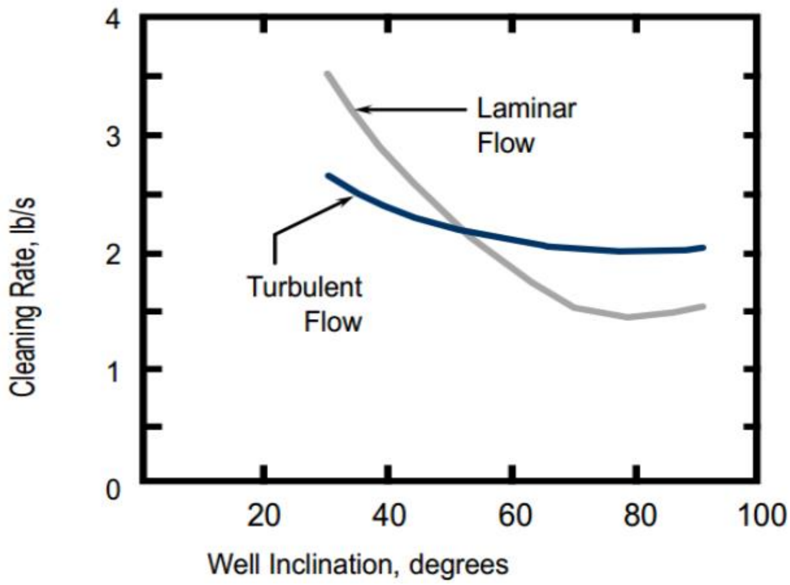


Figure 37: Cleaning of the well according to the inclination and flow regime **[36]**

4 Problems according of bad Wellbore cleaning:

Here are some potential problems that can arise from poor wellbore cleaning:

4.1 Increase torque and drag:

Drilled drills are not transported out of the hole due to low annular velocity and poor mud properties when circulation is stopped, drills fall back into the holes and clog the drilling fittings The torque is the rotation resistance of the drill, and drag is the resistance to the rise or descent of the Drill. These traction and rotation losses are due to the accumulation of debris in the different sections of the well and especially the deviated wells [37].

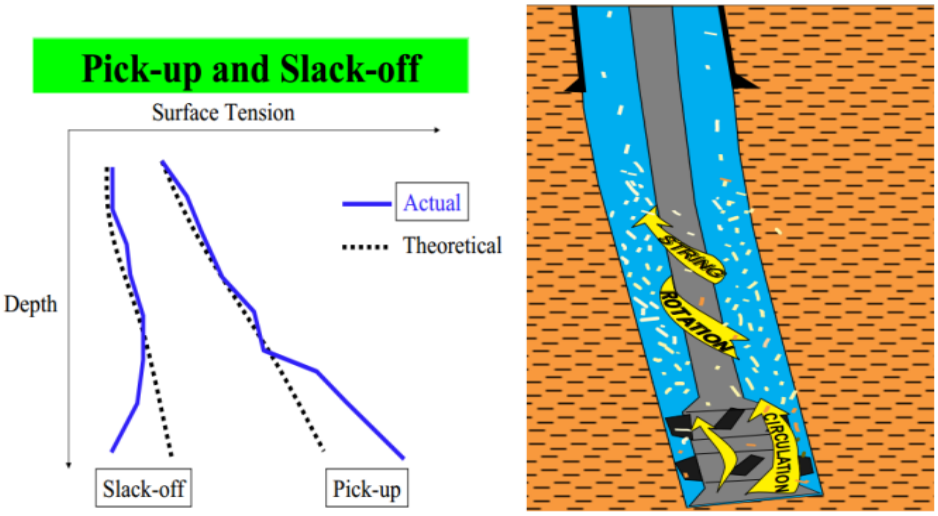


Figure 38: Increase in torque and drag due to debris **[37]**

4.2 Stuck pipe:

Skipping a cleaning step can be costly. When cuttings aren't removed effectively, they pile up in the space around the drill pipe. This narrows the passage and creates more friction between the pipe and the wellbore. The tighter the cuttings pack, the harder it becomes to move the pipe, raising the risk of a costly stuck pipe situation [38].

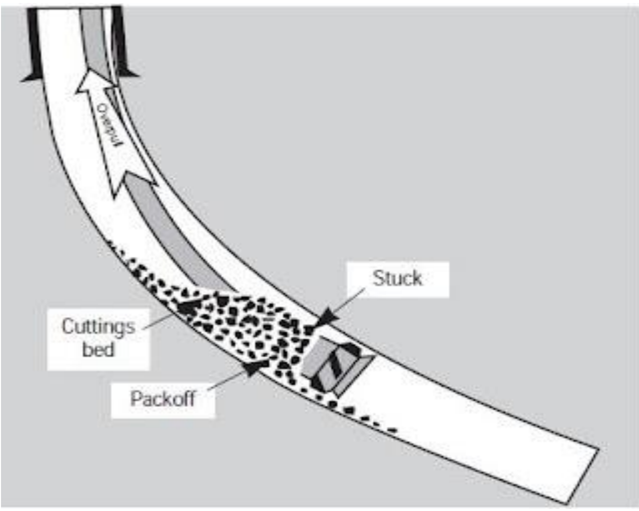


Figure 39: Stuck pipe due to poor cleaning **[39]**

4.3 Wellbore instability:

Wellbore instability, or the inability of a wellbore to maintain its shape and integrity under various pressures, can be caused by inadequate mud weight or rheology, poor hole cleaning or cementing, formation heterogeneity or anisotropy, thermal or chemical effects, and weak or reactive rock properties. In many cases, poor cleaning procedures can lead to instability and a range of problems, including lost circulation, stuck pipe, and hole collapse [40].

4.4 Reduced drilling efficiency:

Failing to keep a clean wellbore significantly hinders drilling efficiency, Cuttings and debris left behind act like roadblocks within the wellbore, impeding the flow of drilling fluids. This critical fluid circulation aids in removing drilled material, cooling the drill bit, and maintaining wellbore pressure. Restricted fluid flow due to poor cleaning disrupts these vital functions, leading to slower drilling progress and potentially requiring additional cleaning runs, further extending drilling time [41].

4.5 Bad cementing operations:

Inadequate wellbore cleansing can go away in the back of drilling cuttings, dust cake, and different debris in the wellbore, which can interfere with the cementing method. These contaminants can prevent an awesome bond between the cement and the formation, as well as the casing, leading to capability channelling or micro-annuli. This can bring about negative zonal isolation, allowing unwanted fluid migration between formations, and compromising the integrity of the properly. Additionally, the presence of cuttings and debris can motive premature setting or contamination of the cement slurry, similarly exacerbating the cementing problems [42].

4.6 High return cost:

Inadequate elimination of drilling cuttings and debris from the wellbore can result in multiplied non-productive time (NPT) and better standard expenses. Excessive cuttings accumulation can purpose problems including stuck pipe, formation damage, and untimely bit put on, main to high-priced fishing operations, side-tracking, or maybe well abandonment. Additionally, bad cleansing can compromise cementing operations, requiring remedial cement squeeze jobs or contributing to sustained casing pressure troubles, further escalating expenses [43].

Conclusion

Therefore, achieving effective hole cleaning is paramount throughout the drilling operation. By continuously removing cuttings and maintaining a clean wellbore, well integrity is protected, allowing for efficient drilling progress, cost optimization, and ultimately, the successful completion of the project.

Chapter III : Case Study the Well of Cenz-08

1 INTRODUCTION TO THE WELL OF CENZ-08:

The field of Chabet En-Nekhla is at the center of the region of METLILI & GHARDAIA, at 16 km south-west of the city of METLILI, and at 25 km south-west of Ait Kheir.

This well was discovered at 2016 by the drilling of CEN-1 proved existence Of hydrocarbons at the presence of "A + B" at the trasic era. The first exploitation of Chabet En-Nekhla is at the central outskirts of the search of city GHARDAIA.

At block at the northern parts of the sahara with a net worth of 49.77 km². the main reservoirs are the triassic reservoirs that are located at the lower and higher level by the levels (A,B,C) interspersed with clay layers. Two seismics were used to carry out the delimitation of CENZ-8: 11-GHA-3D required and processed by BGP, 15-MET-3 acquired by BGP and processed by ENAGEO.

ENAGEO carried out a post-stack fusion of these seismic data to evaluate the structures located in the overlap zone. Previous geological, geophysical and reservoir work on the Chabet field En Nekhla allowed the total volume of oil and condensate in place to be assessed for the Triassic sandstone and to derive predicted oil production profiles which were used to configure the surface facilities required to process the production. The surface facilities necessary to process the production of this field. The oil and condensates produced by the CENZ-8 well will be transported to the Oued Noumer processing plant where they will be treated.

The well will begin in the Turonian limestones and dolomites and will end at a depth of 3110m MD in a horizontal drain of TAG-A.

2 General informations:

Table 2: general information of CENZ-08 well

Country	Algeria
Wilaya	Ghardaïa
location	Oued Mya
perimeter	Chabet En-Nekhla
Area location	420a
Name of well & abbreviation	Chabet En-Nekhla Horizontal-08 / CONZ-08
Company	Sonatrach
Drilling contractor	Enafor
Type of well	Horizontal
Drilling classification	Development

3 Location:

The CENZ-8 well is located north of the Saharan plateau, at the western end of the Triassic province.

At an average altitude of 555 m above sea level, located to the north of the perimeter operating site of Chabet En-Nekhla on block 420, it is located 650 km south of Algiers, approximately

80 km north of the town of Ghardaïa. The landscape is made up of a vast rocky plateau and a climate characterized by low rainfall (130 mm/year) and average humidity of 18% in summer and 30% in winter.

This establishment is located to the west of the Ait El kheir and Oued Noumer fields and at:

- 1393 m north of well CEN-005.
- 1947 m northwest of well CEN-003.

Table 3: Coordinates (UTM & Geographies) of the well

UTM 31		**Géographique**	
Easting (X)	***Northing (Y)***	***Latitude (N)***	***Longitude (E)***
567 729.966m	3 587 283.613m	32°25'22.92548" N	3°43'13.27124" E
Zs= **555.294 m**		Zt= **562.954 m**	

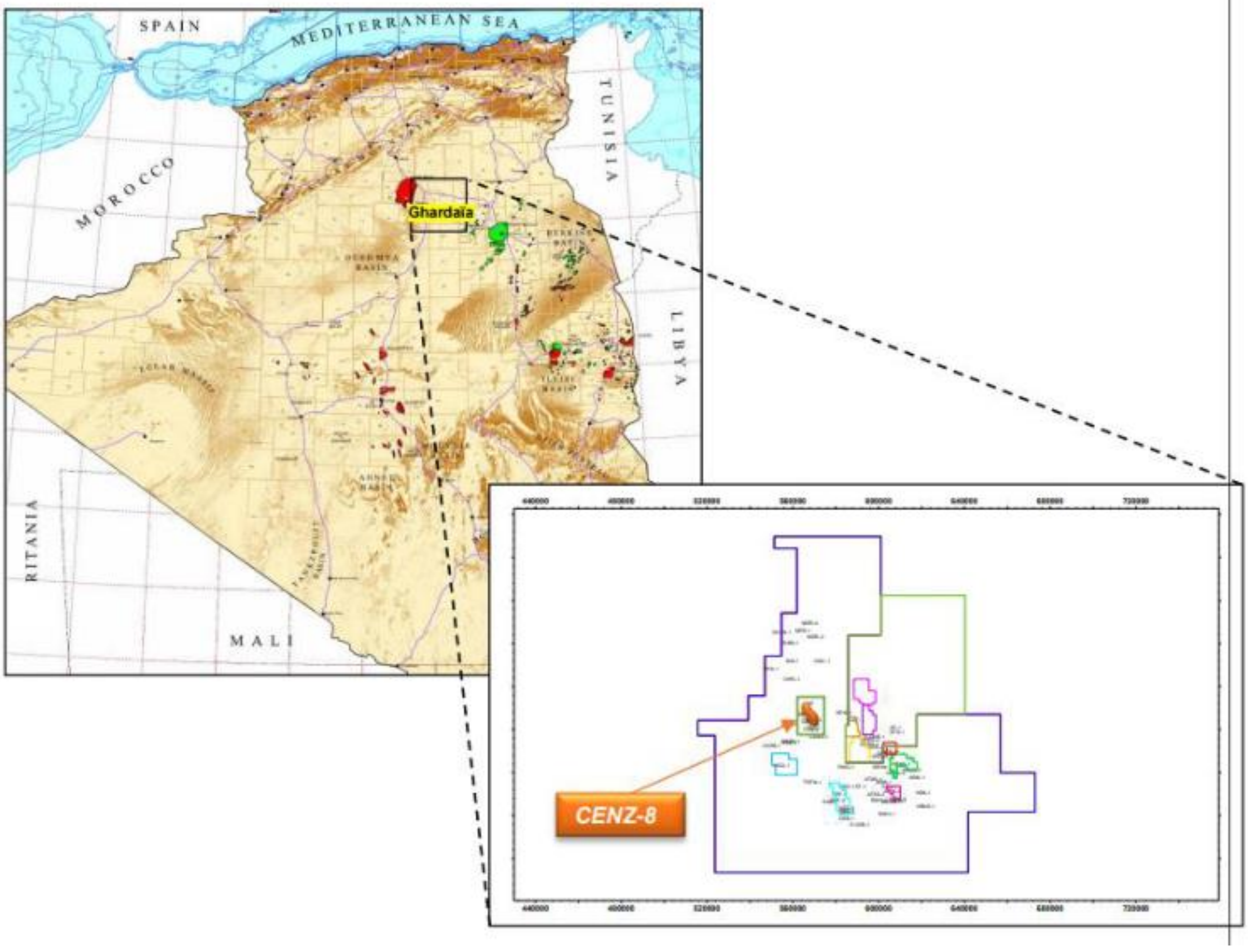


Figure 40: Geographical situation and location of the CENZ-08 borehole

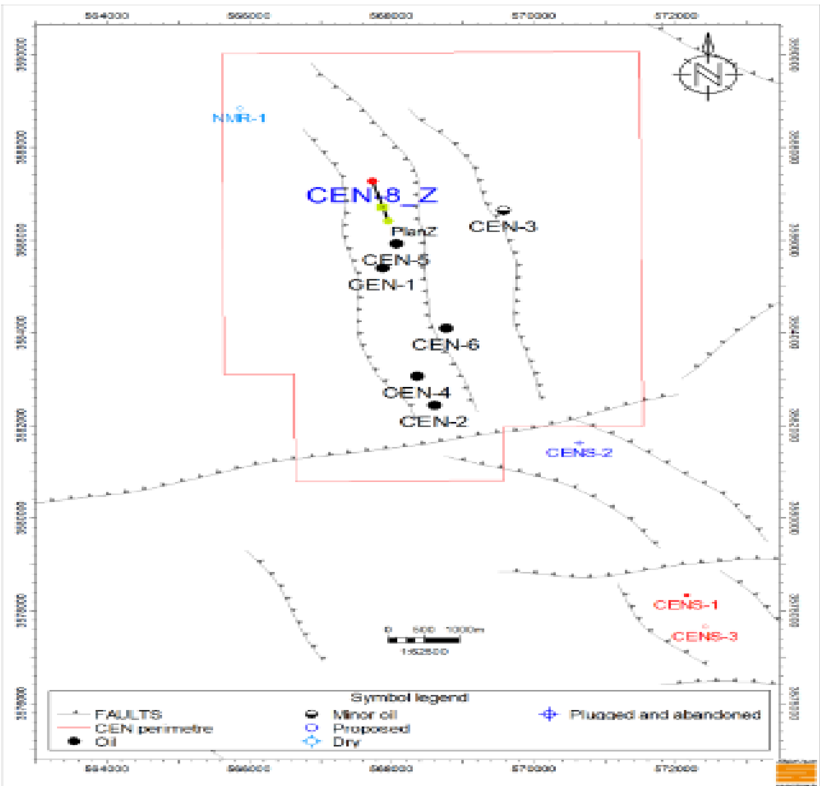
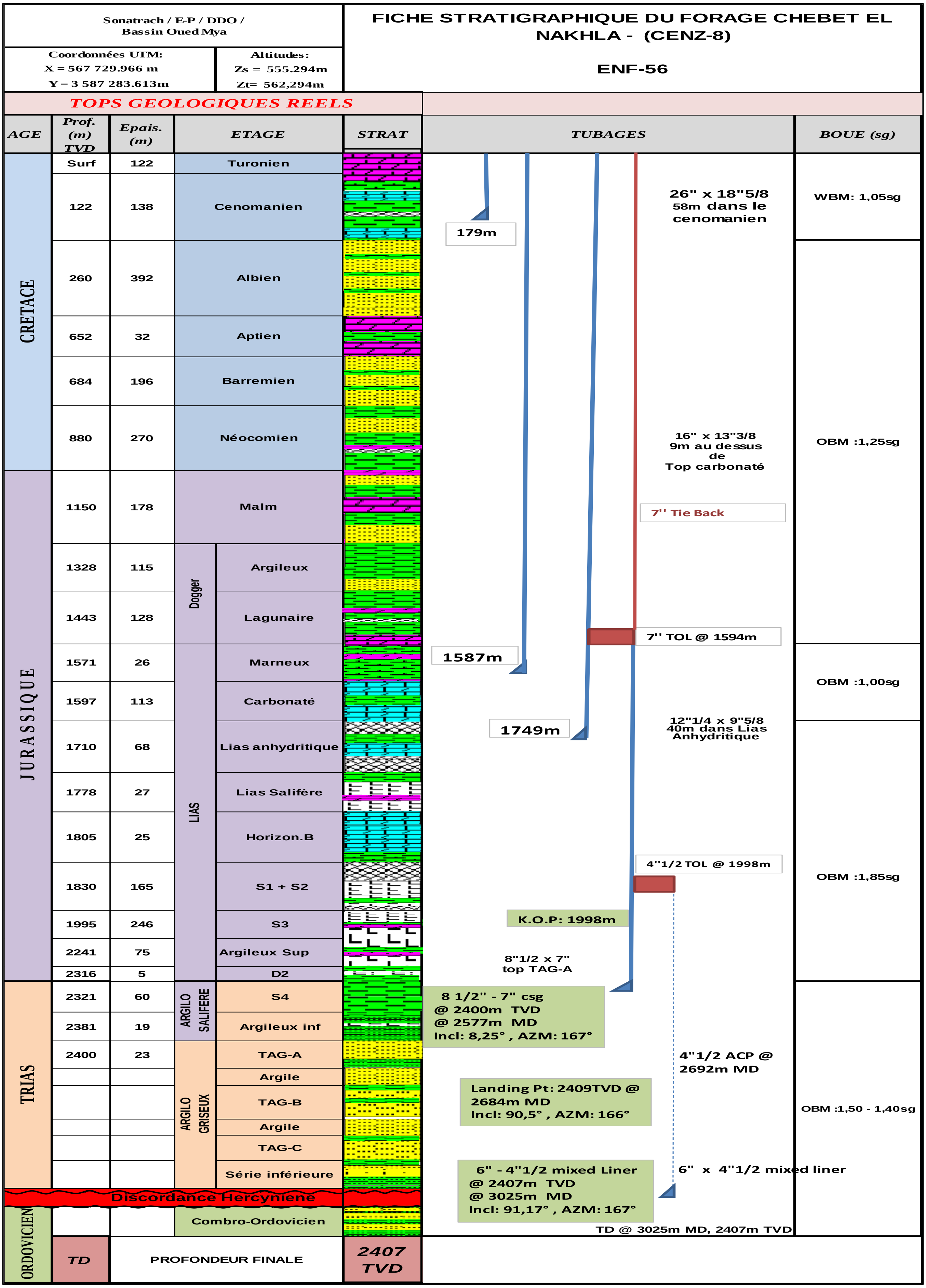


Figure 41: Survey position lan CENZ-08

MasterLog:


Sonatrach / E-P / DDO / Bassin Oued Mya
Coordonnées UTM: X = 567 729.966 m Y = 3 587 283.613m
Altitudes: Zs = 555.294m Zt= 562,294m
FICHE STRATIGRAPHIQUE DU FORAGE CHEBET EL NAKHLA - (CENZ-8)
ENF-56
TOPS GEOLOGIQUES REELS
AGE
Prof. (m) TVD
Epais. (m)
ETAGE
STRAT
TUBAGES
BOUE (sg)
CRETACE
JURASSIQUE
TRIAS
ORDOVICIEN
Surf 122 Turonien
122 138 Cenomanien
260 392 Albien
652 32 Aptien
684 196 Barremien
880 270 Néocomien
1150 178 Malm
Dogger
1328 115 Argileux
1443 128 Lagunaire
LIAS
1571 26 Marneux
1597 113 Carbonaté
1710 68 Lias anhydritique
1778 27 Lias Salifère
1805 25 Horizon.B
1830 165 S1 + S2
1995 246 S3
2241 75 Argileux Sup
2316 5 D2
ARGILO SALIFERE
2321 60 S4
2381 19 Argileux inf
ARGILO GRISEUX
2400 23 TAG-A
Argile
TAG-B
Argile
TAG-C
Série inférieure
Discordance Hercynienne
Combro-Ordovicien
TD
PROFONDEUR FINALE
2407 TVD
179m
26" x 18"5/8 58m dans le cenomanien
16" x 13"3/8 9m au dessus de Top carbonaté
7'' Tie Back
1587m
7'' TOL @ 1594m
1749m
12"1/4 x 9"5/8 40m dans Lias Anhydritique
4"1/2 TOL @ 1998m
K.O.P: 1998m
8"1/2 x 7" top TAG-A
8 1/2" - 7" csg @ 2400m TVD @ 2577m MD Incl: 8,25° , AZM: 167°
4"1/2 ACP @ 2692m MD
Landing Pt: 2409TVD @ 2684m MD Incl: 90,5° , AZM: 166°
6" - 4"1/2 mixed Liner @ 2407m TVD @ 3025m MD Incl: 91,17° , AZM: 167°
6" x 4"1/2 mixed liner
TD @ 3025m MD, 2407m TVD
WBM: 1,05sg
OBM :1,25sg
OBM :1,00sg
OBM :1,85sg
OBM :1,50 - 1,40sg

4 Property of drilling mud:

The mud used in drilling of the phase 16″ on the well CONZ-08 is a mud of OBM of type EMEC System that is a drilling mud of inversed émulsion with a rappot « Oil/water »=« 70/30 & 85/15», sa densité est de « 1.25».

As its represented on the next table:

Table 4: properties of drilling mud

PROPRETIES	REQUIREMENT
Mud Type	EMEC OBM
Mud Weight	1.25
Plastic Viscosity	ALAP
Yield Point	18-24
Ratio Oil/water	70-30/85-15
HP HT filtrate	Lower than 4
Alkalinity Mud Pm	3.5-4
Electric Stability	Higher than 600
LGS	Lower than 5

The database (inputs):

- Drillstrings data.
- Test results on drilling mud (Fann).
- Drilling parameters.

The 16” phase was drilled between 426.64m and 2678m. The packing used is:

Drill pipe class p 5"1/2-21.90 from ID = 4.778 in.

Drill pipe class p 5"-19.50 from ID =4.276 in.

Heavy rod OD = 5 in.

Rod weight OD = 8 in.

Rod weight OD = 9.5 in.

Table 5: Drillstring data

STRING	TYPE	OD (in)	ID (in)	Kg/m	Length (m)	V.int (l/m)	V.int Total (L)	V.external (L/m)
DP1	5”1/2-21.9 #G105 class P	5.356	4.778	32.5907	426.64	11.5677	4935.3	14.5357
DP2	5”1/2/ -19.5 #G105 class P	4.855	4.276	29.0192	920.09	9.2647	8524.3	11.9436
HWDP	5”*3”	5	3	86.45	57.94	4.5603	264.2	12.6676
DC	8”*2 12/16”	8	2.813	223.04	18.48	4.0095	40.5	32.4292
JAR	8”*2 13/16”	8	2.813	223.04	10.09	4.0095	501	32.4292
DC	8”*2 13/16”	9.5	3	323.11	39.91	4.5603	182	32.4292
DC	9”1/2*3”	18.625	17.775	130.254	477	160.094	76365.1	45.7303

5 Drilling parameters and mud test results:

The table below shows the rheological parameters and drilling parameters and the test results on the drilling mud used (speed 600 rpm, 300 rpm, 200 rpm).

Table 6: Drilling parameters and mud test results

TEST MUD			DRILLING PARAMETERES	
Rpm speed	Reading per 1 second		Mud density (sg)	1.25
600	50		Drilling flow (l/min)	2491
300	35		Diameter cutting (in)	0.3
200	20		Deinsty cutting (sg)	2.7
100	22		TFA BIT (in^2)	0.944
6	17		Max permitted surface pressure (psi)	3980
3	12		Pumps pressure (HP)	1600
MUD PUMP	LINER(in)		Course (in)	Efficiency (%)
Pump1	6.5		12	97
Pump 2	6.5		12	97

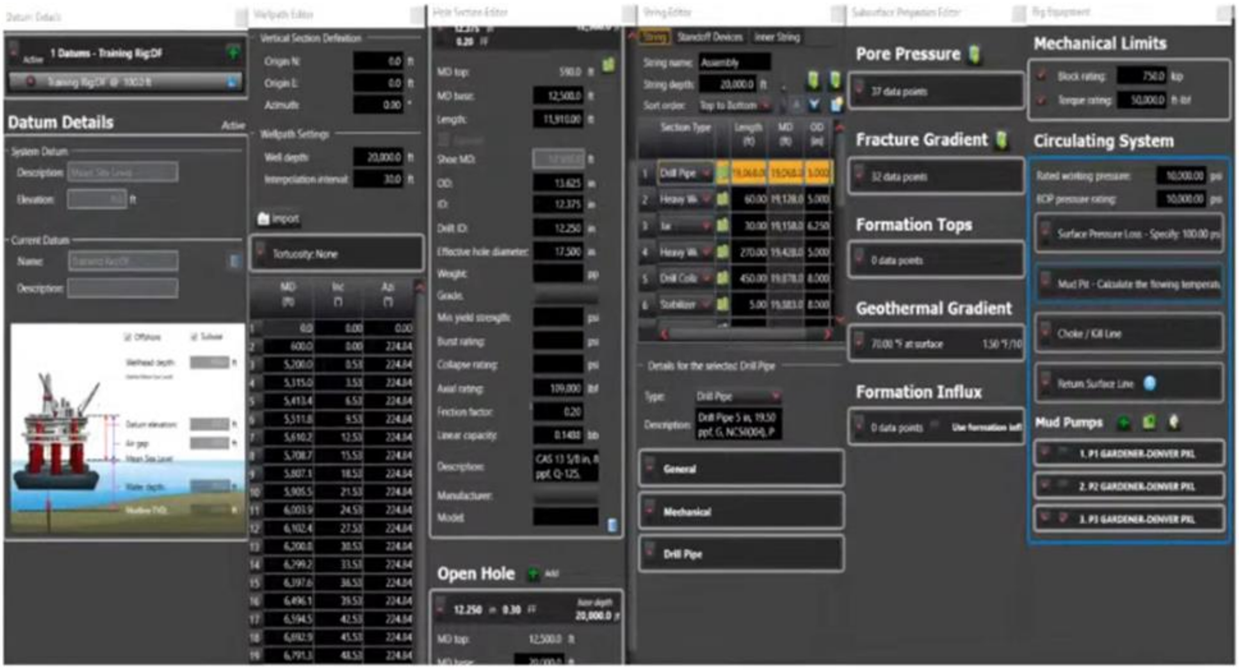
6 Simulation:

Using Haliburton's WellPlan we have:

Halliburton WellPlan is a heavyweight software program within the oil and gas industry, Core Functionality: Well String Design.

WellPlan revolves around designing the placement of pipes, or casings, that form the wellbore's lining. These casings are crucial for several reasons:

- **Maintaining wellbore integrity**: They prevent the wellbore from collapsing and isolate different formation zones encountered during drilling.
- **Ensuring well control**: They provide a pathway to circulate drilling fluids, which control pressure and prevent unwanted influxes from the reservoir.
- **Facilitating production**: They serve as a conduit for hydrocarbons to flow to the surface after well completion.



WellPlan helps engineers optimize this process by:

Performing intricate wellbore calculations: The software incorporates powerful engineering algorithms to assess factors like stresses, loads, and pressure throughout the wellbore under various conditions.

Analyzing various wellbore scenarios: Engineers can model different casing configurations, mud types, and drilling parameters to identify the most suitable and cost-effective design.

Visualizing wellbore data: WellPlan offers user-friendly data visualize

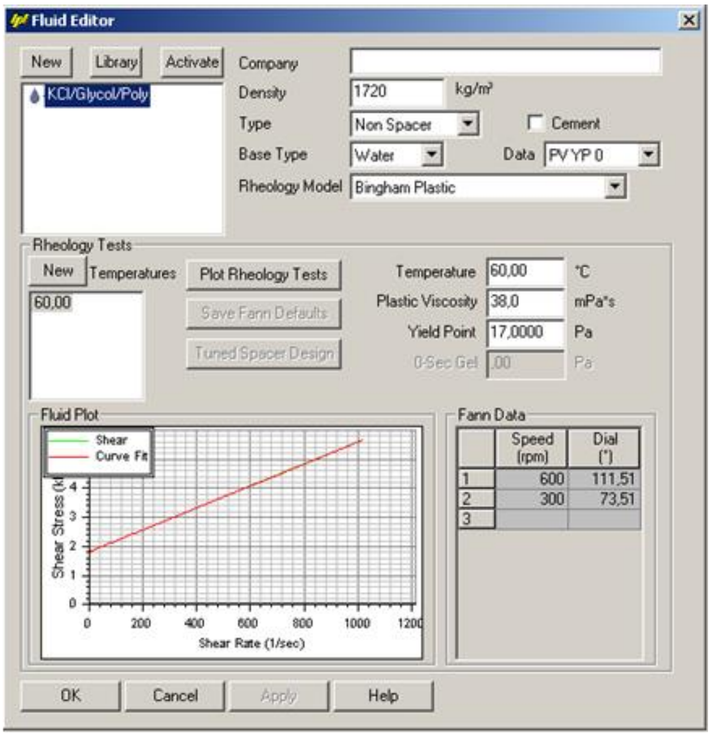
Efficiency and Cost-Effectiveness WellPlan goes beyond just design.

It's built to streamline the well string design workflow, leading to significant benefits:

- **Reduced design time**: By automating calculations and offering a user-friendly interface, WellPlan cuts down on the time needed to design wellbores.

- **Enhanced decision-making**: The ability to analyze various scenarios empowers engineers to make optimal choices regarding casing selection, drilling procedures, and overall well construction strategy.
- **Minimized errors**: WellPlan's robust calculations and data visualization features help reduce the risk of errors during the design phase, saving time and resources in the long run. By optimizing wellbore design and minimizing errors, WellPlan contributes to cost reduction in well construction, a critical factor for oil and gas companies.
- **Integration with Other Well Construction Tools:** WellPlan isn't a standalone program. It functions within Halliburton's broader DecisionSpace 365 suite, seamlessly integrating with other well construction applications like Engineer's Desktop (EDT) [5]. This integrated environment allows engineers to share data and designs across different software modules, fostering better collaboration and improving overall well construction efficiency.

In essence, Halliburton WellPlan is an industry-standard software solution empowering wellbore engineers to design safe, efficient, and cost-effective wellbores. It simplifies complex calculations, streamlines workflows, and integrates with other well construction tools, making it a vital asset for the oil and gas industry.



- **Fluid**: Here you should enter the fluid data. You can add more than one fluid and choose which one is circulating at different situations.

7 Introduction:

In this chapter, the drilling parameters used are presented, such as the technical characteristics of the drilling pumps, as well as the drilling flow rate and the rheological parameters of the drilling fluid used for cleaning, and the results of the applied study of the impact of these parameters on well cleaning are discussed.

8 Part of Calculation and Simulation:

8.1 Rheology and volume:

Table 7: MUD RHEOLOGY

MUD RHEOLOGY	
Mud type	BINGHAM
Power low index (n)	0.542876688
Consistance index (lb/100 ft2)	1.42369962
Viscosité plastique (cp)	15
Yield point (lb/100 ft2)	20

8.2 Pump volumes and characteristics:

Using the drilling parameters and information displayed in the database, the results were as follows:

Table 8: The volumes and characteristics of drilling pumps

VOLUME	
INT (m_3)	15.5736843
ANNULAR (m3)	205.9376867
TOTAL (m_3)	224.511371
SPM P1 + P2 To get Q	137.5 spm
Surface to bit p1+p2	5.87 min
	0.12 hr
LAG time p1+p2	782 strocks
	82.695 min
	1.58 hr
Bottom up	10623.5 strocks
	1.27 hr
Cycle	1.43 hr
	11401.5 strocks

Table 9: Friction loss and flow regime inside the Drill String

Section	Long (m)	ID (in)	Vmoy (ft/min)	Vc (ft/min)	flow regimes	Friction loss (psi)	Qc (l/min)
Inside DP1	247.02	4.778	773.76	295.01	Turbulent	73.03	966.1223278
Inside DP2	920.09	4276	966.11	307.44	Turbulent	780.07	979.1721847
Inside HWDP	55.97	3	1,962.72	350.76	Turbulent	137.22	1319.467533
Inside DC	18.24	2.813	2,232.35	359.27	Turbulent	60.66	1440.489215
Inside JAR	9.645	2.813	2,232.35	359.27	Turbulent	32.27	1440.449215
Inside DC	117.97	2.813	2,232.35	359.27	Turbulent	395.62	1440.489215
Inside DC	27.655	3	1,962.72	350.76	Turbulent	72.83	1319.467533

Table 10: Friction loss and flow regime in the annular space

Section	Long (m)	ID (csg/hole) (in)	OD (dp/dc/hw) (in)	De (in)	Vmoy (ft/min)	Vc (ft/min)	flow regimes	Friction loss (psi)
DP1 /Csg	247.02	17.775	5.428	12.347	61.49223891	323.15	Laminar	6.06
DP2 /Csg	88.98	17.775	4.9275	12.8475	60.41632074	323.12	Laminar	2.22
DP2/hole	831.11	16	4.9275	11.0725	75.9995594	323.225	Laminar	45.45
HWDP/ O.Hole	55.97	16	5	11	76.46969564	323.24	Laminar	1.615
DC-JAR DC/Open.Hole	145.855	16	8	8	92.0026139	323.575	Laminar	5.855
DC2 / O.Hole	27.655	16	9.5	6.5	106.5731505	323.915	Laminar	1.36

Table 11: Friction Loss

FRICTION LOSS	
SUFACE (psi)	418.9700247
INT STRING (psi)	1551.705
ANNU (psi)	62.555
BIT (psi)	552.518854
Friction loss Cycle (psi)	2585.748818

8.3 Cleaning efficiency in different well sections:

Cleaning efficiency refers to the ability of the drilling fluid to remove cuttings from the wellbore during drilling operations. It is a crucial factor for maintaining wellbore integrity and achieving optimal drilling performance. Cleaning efficiency can vary depending on the section of the well being drilled.

Table 12: Cleaning efficiency in different well sections

CLEANING (%)	
DP/Csg	68.03596176
DP/Hole	72.95568027
HWDP/O.Hole	73.04235015
DC-JAR-DC/O.Hole	75.79324296
DC2/O.Hole	77.93300704

Table 13: Influence of flow on Annular Velocity and Cleaning

(YP=19, VP=16, d Mud =1.25, diameter cutting=0.3 m)			
Flow Rate (l/ min)	**Friction loss (psi)**	**Vann (ft/min)**	**Cleaning (%)**
0	0	0	0
200	226.89	5.78	-138.19
400	244.99	11.55	-31.49
600	302.95	17.33	7.12
800	375.19	23.1	27.42
1000	503.49	28.88	40.05
1200	674.62	34.65	48.73
1400	871.41	40.43	55.07
1600	1093.25	46.21	59.93
1800	1339.62	51.98	63.78
2000	1610.09	57.76	66.91
2200	1904.27	63.53	69.5
2400	2221.81	69.31	71.7
2600	2562.42	75.09	73.57
2800	2925.8	80.86	75.2
3000	3311.72	86.64	76.62
3200	3719.93	92.41	77.88

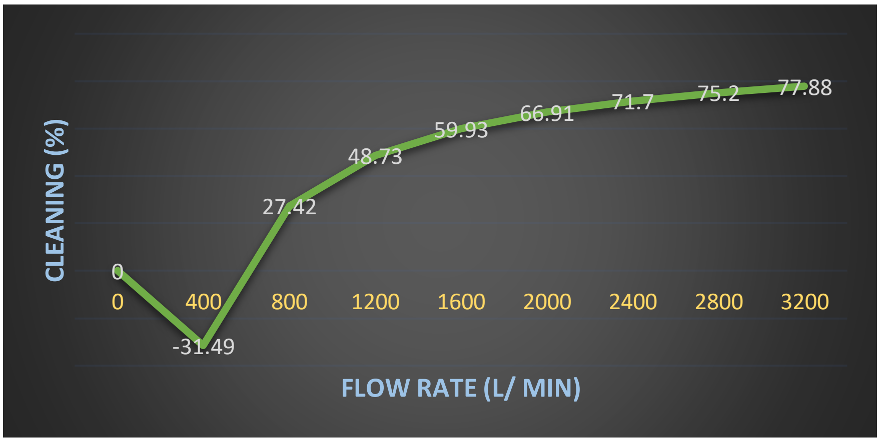


Figure 42: Cleaning efficiency based on drilling flow

The data points plotted on the graph suggest that the flow rate starts at around 27.
42 L/MIN and increases to a peak of around 80 L/MIN. The flow rate then fluctuates somewhat before settling around 60 L/MIN for the majority of the recorded period. There is a brief drop towards the end to around 40 L/MIN.

Which in turn means that a:

- **Increased Flow Rate:** A higher flow rate translates to greater fluid velocity. This enhanced velocity improves the carrying capacity of the drilling fluid, enabling it to transport cuttings more effectively away from the drill bit and up the annulus (the space between the drill pipe and the wellbore wall). This reduces the risk of cuttings accumulating around the drill bit, which can hinder drilling performance and lead to problems like sticking the drill pipe.

- **Optimal Flow Rate**: There is an optimal flow rate for maximizing cleaning efficiency. Excessively high flow rates can erode the wellbore wall and increase drilling costs. Conversely, flow rates that are too low may not be sufficient to remove cuttings effectively, leading to the aforementioned problems.

Table 14: The impact of the report (Yp/Vp) on cleaning efficiency

YP/VP						
Q=1500 (l/min)				Q=1000 (l/min)		
YP/VP	**Friction loss (SYST)**	**Cleaning (%)**		**YP/VP**	**Friction loss (SYST)**	**Cleaning (%)**
0.4	980.43	43.24		0.4	487.6	17.4
0.46	981.5	45.17		0.46	490.6	20.5
0.52	982.21	47.07		0.52	492.6	23.5
0.59	982.58	48.92		0.59	494.8	26.4
0.67	982.61	50.74		0.67	496.9	29.3
0.75	982.3	52.53		0.75	498.8	32.1
0.84	981.65	54.27		0.84	500.4	34.8
0.94	980.63	55.98		0.94	502.1	37.5
1.06	979.23	57.65		1.06	503.5	40.1
1.19	977.42	59.29		1.19	504.8	42.6
1.33	975.18	60.88		1.33	504.8	45
1.5	972.46	62.44		1.5	504.7	47.4
1.69	969.2	63.96		1.69	504.3	49.8
1.92	965.35	65.44		1.92	503.6	52
2.18	960.83	66.88		2.18	511.4	54.2

Impact of (Yp/Vp) Ratio on Cleaning Efficiency:

The provided text discusses the influence of the (Yp/Vp) ratio on cleaning efficiency in different well sections, considering constant flow rates of 1000 l/min and 1500 l/min.

Influence of Increasing (Yp/Vp) Ratio:

An increase in the (Yp/Vp) ratio, which represents the relationship between yield point (Yp) and plastic viscosity (Vp) of the drilling fluid, leads to an enhancement in cleaning efficiency.

This is attributed to two primary factors:

- **Improved Cuttings Transport**: A higher (Yp/Vp) ratio indicates a drilling fluid with better carrying capacity, meaning it can more effectively transport cuttings away from the drill bit. This is particularly beneficial in deviated and horizontal wells, where cuttings tend to accumulate due to reduced gravitational forces.
- **Reduced Shear Stress**: While a higher (Yp/Vp) ratio implies increased yield point, it can also lead to lower plastic viscosity under shear conditions. This can be beneficial for cleaning efficiency as lower plastic viscosity allows the fluid to flow more easily around cuttings and mobilize them more effectively.

Impact of Flow Rate:

The influence of increasing flow rate on certain variables. A higher flow rate of 1500 l/min compared to 1000 l/min leads to:

- **Increased Cutting Velocity**: The velocity of cuttings traveling along the wellbore increases with a higher flow rate. This further enhances their removal from the drilling zone.
- **Reduced Pressure Drop**: The provided text seems to contradict the general understanding that increasing flow rate typically leads to a higher pressure drop. However, it's possible that specific wellbore conditions or drilling fluid properties could influence this relationship.

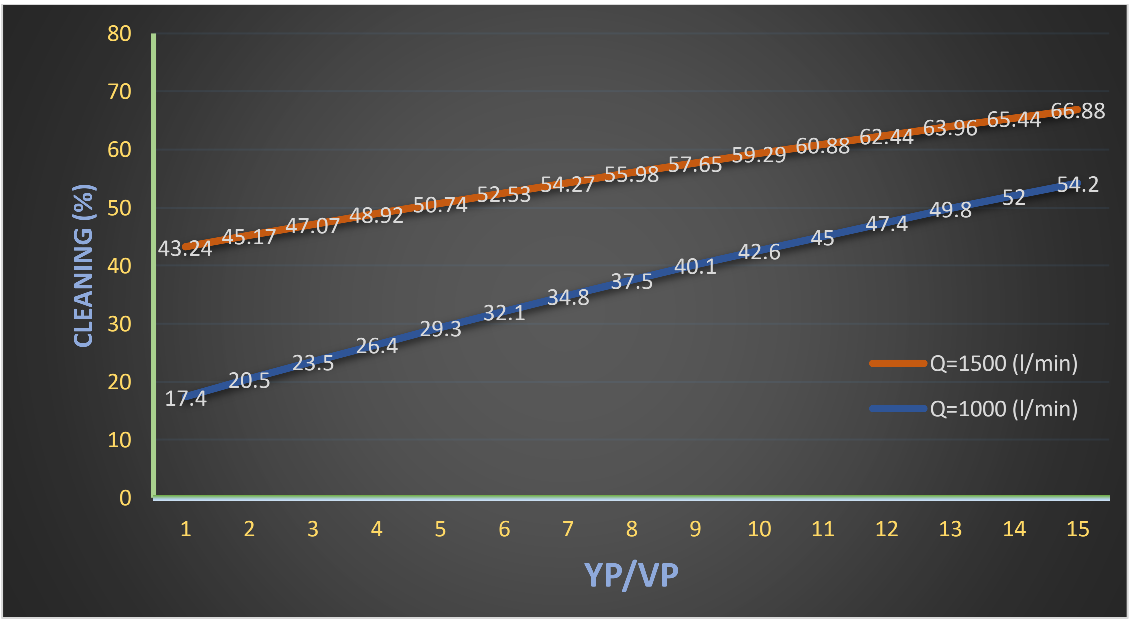


Figure 43: Cleaning efficiency based on the report (Yp/Vp)

In drilling operations, YP (yield point) and VP (plastic viscosity) are two crucial rheological properties of drilling fluid that influence cleaning efficiency.

- **Yield Point (YP):** The YP represents the minimum shear stress required to initiate flow in the drilling fluid. A higher YP indicates a higher resistance to flow at low shear rates.
- **Plastic Viscosity (VP):** The VP characterizes the drilling fluid's resistance to shear thinning at higher shear rates. A lower VP indicates a more shear-thinning fluid, which can be beneficial for carrying cuttings.

These properties are interrelated and can be measured using a viscometer. Generally, a drilling fluid with a low YP and a low VP is desirable for promoting good cleaning efficiency. This is because such a fluid will have a lower shear stress at the drilled hole wall while still exhibiting good carrying capacity to transport cuttings away from the drill bit.

Table 15: The influence of density on cleaning efficiency

Density						
Q=1000 (l/min)				Q=1500 (l/min)		
d	Friction loss (psi)	Cleaning (%)		d	Friction loss (psi)	Cleaning (%)
1.25	491.2	37.4367		1.25	950.04	55.8
1.26	493.9	37.9649		1.26	955.89	56.18
1.27	496.5	38.4905		1.27	961.73	56.55
1.28	499.2	39.0136		1.28	967.57	56.92
1.29	500.7	39.5343		1.29	973.41	57.29
1.3	503.5	40.0525		1.3	979.23	57.65
1.31	506.3	40.5684		1.31	985.05	58.02
1.32	509	41.082		1.32	990.86	58.38
1.33	511.8	41.5934		1.33	996.66	58.74
1.34	514.5	42.1027		1.34	1002.5	59.1
1.35	517.3	42.6098		1.35	1008.2	59.46
1.36	520	43.115		1.36	1014.3	59.82
1.37	522.7	43.6181		1.37	1019.8	60.17
1.38	525.5	44.1193		1.38	1025.6	60.53

The impact of drilling fluid density on cleaning efficiency in different well sections,

- considering constant flow rates of 1000 l/min and 1500 l/min.

Influence of Increasing Density:

An increase in drilling fluid density leads to an enhancement in cleaning efficiency. This is attributed to two primary factors:

- **Increased Settling Velocity**: As density increases, the settling velocity of cuttings also increases. This means that cuttings are more likely to fall away from the drill bit and travel down the wellbore under the influence of gravity.
- **Enhanced Shear Stress**: Higher fluid density results in elevated shear stress, which can better mobilize and transport cuttings. This is particularly beneficial in deviated and horizontal wells, where cuttings tend to accumulate due to reduced gravitational forces.

Impact of Flow Rate:

The text also highlights the influence of increasing flow rate on certain variables. A higher flow rate of 1500 l/min compared to 1000 l/min leads to:

- **Increased Cutting Velocity**: The velocity of cuttings traveling along the wellbore increases with a higher flow rate. This further enhances their removal from the drilling zone.
- **Reduced Pressure Drop**: The provided text seems to contradict the general understanding that increasing flow rate typically leads to a higher pressure drop. However, it's possible that specific wellbore conditions or drilling fluid properties could influence this relationship.

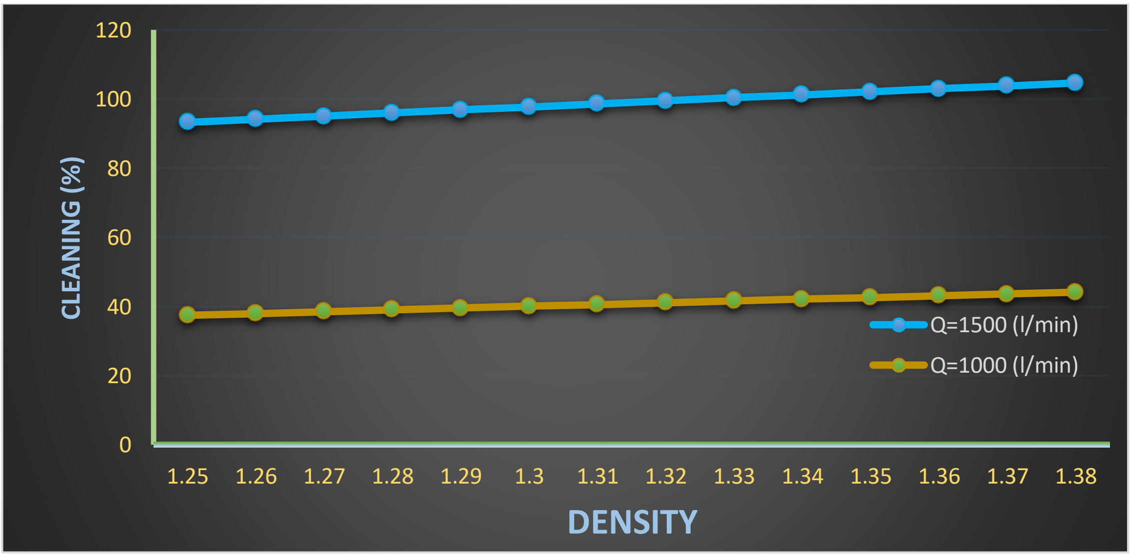


Figure 44: Cleaning efficiency based on the density

CONCLUSION

After the data and results, we conclude that the initial velocity is proportional to Pumping increases debt better when cleaning. On constant equality Rheological properties directly affect cleaning. as YP/VP relationship the best 1 improves cleaning while maintaining the ratio with reduction Plastic viscosity of a good solid or increased ratio to water or water Increase the production point and add viscous products to achieve a good result cleaning efficiency in addition to improving density through cleaning, increased by 10 points We will improve cleaning by just 5%. The basic procedure to ensure high efficiency of the cleaning process is Constant control of torque, weights and traction, ROP, cutting quantities transported to the surface.

GENERAL CONCLUSION

While meticulous maintenance of drilling mud is crucial, ultimate success hinges on a well-chosen mud system and a deep understanding of potential mud-related problems. Furthermore, achieving effective hole cleaning throughout the drilling process is paramount.

By continuously removing cuttings and maintaining a clean wellbore, well integrity is safeguarded, enabling efficient drilling progress, cost optimization, and ultimately, project completion.

This emphasizes the importance of factors beyond mud maintenance, including proper mud selection, rheological properties, and continuous monitoring of drilling parameters like torque, weight on bit, and rate of penetration, all of which contribute significantly to efficient cleaning and a successful drilling operation.

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