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Minimization of organic and inorganic deposits from two wells in oil field

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With our most sincere thanks.

(SEBA Mahddi, BOUKHOBZA Med Nazim)

DEDICATION

To my parents, my brother and sisters, my maternal uncle, who have always been my pillars and my source of inspiration.

To my supervisor, TABCHOUCHE Ahmed, for his patience, his expertise and his valuable advice. Your mentorship guided me throughout this academic journey and allowed me to surpass myself.

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(SEBA Mahddi)

DEDICATION

First, I dedicate this thesis to “ALLAH” my Creator, and the Source of all knowledge and wisdom, with profound gratitude and reverence. It is with complete humility that I acknowledge your infinite blessings and guidance that have shaped every step of my journey.

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(BOUKHOBZA Med Nazim)

Tables List

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Abbreviations List

EDTA: ethylene diamine tetra-acetic acid

HEDP: sodium hydroxyethyl phosphonate

AMP: aminomethylphosphonate

PBTC: 2-phosphonobutane-1,2,4-tricarboxylic acid

SNF: naphthalene formaldehyde sulfonate

ATMP: aminotrimethylene

MDEA: methyl diethanolamine

Contents

Abstract

The minimization of organic and inorganic deposition in two wells in an oil field is a major concern in the petroleum industry. Organic deposits form when hydrocarbons cool and solidify, while inorganic deposits are driven by the precipitation of minerals such as calcium carbonate or calcium sulfate.

These deposits can lead to problems such as clogs in pipes and wells, reduced production throughput, reduced product quality, increased maintenance costs and production downtime.

Minimizing these deposits is critical to maintaining optimum production in oil wells, ensuring product quality, and reducing maintenance and production costs.

Résumé

La minimisation des dépôts organiques et inorganiques dans deux puits dans un champ pétrolier est une préoccupation majeure dans l'industrie pétrolière. Les dépôts organiques se forment lorsque les hydrocarbures se refroidissent et se solidifient, tandis que les dépôts inorganiques sont entraînés par la précipitation de minéraux tels que le carbonate de calcium ou le sulfate de calcium.

Ces dépôts peuvent entraîner des problèmes tels que des obstructions dans les tuyaux et les puits, une réduction du débit de production, une diminution de la qualité du produit, une augmentation des coûts de maintenance et des temps d'arrêt de la production.

La minimisation de ces dépôts est essentielle pour maintenir une production optimale dans les puits de pétrole, assurer la qualité du produit et réduire les coûts de maintenance et de production.

ملخص

يعد تقليل الترسبات العضوية وغير العضوية في بئرين في حقل نفط مصدر قلق كبير في صناعة البترول. تتكون الرواسب العضوية عندما تبرد الهيدروكربونات وتتصلب، بينما الرواسب غير العضوية مدفوعة بترسيب المعادن مثل كربونات الكالسيوم أو كبريتات الكالسيوم.

يمكن أن تؤدي هذه الرواسب إلى مشاكل مثل الانسدادات في الأنابيب والآبار، وانخفاض إنتاجية الإنتاج، وانخفاض جودة المنتج، وزيادة تكاليف الصيانة وتعطل الإنتاج.

يعد تقليل هذه الرواسب أمرًا بالغ الأهمية للحفاظ على الإنتاج الأمثل في آبار النفط، وضمان جودة المنتج، وتقليل تكاليف الصيانة والإنتاج.

General introduction

Oil and gas production is a complex process that involves extracting raw materials from deep geological formations. During this process, oil wells may be exposed to various sources of contamination, including organic and inorganic deposits, which can lead to significant production problems.

Organic and inorganic deposition is generally formed from production water rising from the bottom of wells. Organic deposition results from the growth of microorganisms such as algae and bacteria, while inorganic deposition results from chemical reactions in the production water. These deposits can clog wells; reduce production throughput and increase maintenance and operating costs.

To minimize the effects of organic and inorganic deposits in oil wells, oil companies use a variety of preventive and curative treatment methods. Treatment methods include the use of inhibitors, heat treatments, acid treatments and mechanical treatments. Preventive treatment methods include practices such as oil and gas production management, water quality control, regular monitoring of wells, and the use of inhibitors early in production.

The main objective of minimizing organic and inorganic deposits in oil wells is to maintain stable and regular production while minimizing maintenance and operating costs. By using preventive treatment practices and effective treatment methods, oil companies can reduce the risks and impacts of deposits on oil and gas production.

This study consists of four parts:

- A theoretical part devoted to a theory on oil production, water in oil fields, deposits and their impact on underground and surface installations and their means of combating these harmful and irritant scourges.

- A statistical part, which shows the impact of the deposits on productivity and the methods used to minimize organic or mineral deposits in different wells.

- An experimental part with the purpose of testing the best solvent of organic deposition.

- A general conclusion about our theoretical and practical study and our recommendations about the subject.

Chapter I: Overview of the Hassi-Messaoud field

I.1 Introduction

Hassi Messaoud's field is one of the most complex fields in the world.

Geological science shows us through history, this field has undergone an intense tectonic evolution characterized by compressive and intensive phases.

On the other hand, by the diagenetic transformation in the reservoir during its burial during the geological time, until the deposit took the current configuration.

I.2. Location

The Hassi Messaoud field is 850 km South–South East of Algiers and 350 km from the Tunisian border. Its location in Lambert south Algeria coordinates is as follows:

From [790.000 to 840.000] East.

From [110,000 to 150,000] North.

Figure (I.1): HMD geographical location.

I.3. Geological Situation

The Hassi Messaoud field is the largest oil field in Algeria, covering an area of nearly 2200 km² and is limited to:

To the West by the depression of Oued M'Ya.

South by the mole of Amguid El Bioud.

In the North by the Djamaa-Touggourt structure.

In the East by the shoals of Dahar, Rhourde-El-Baguel.

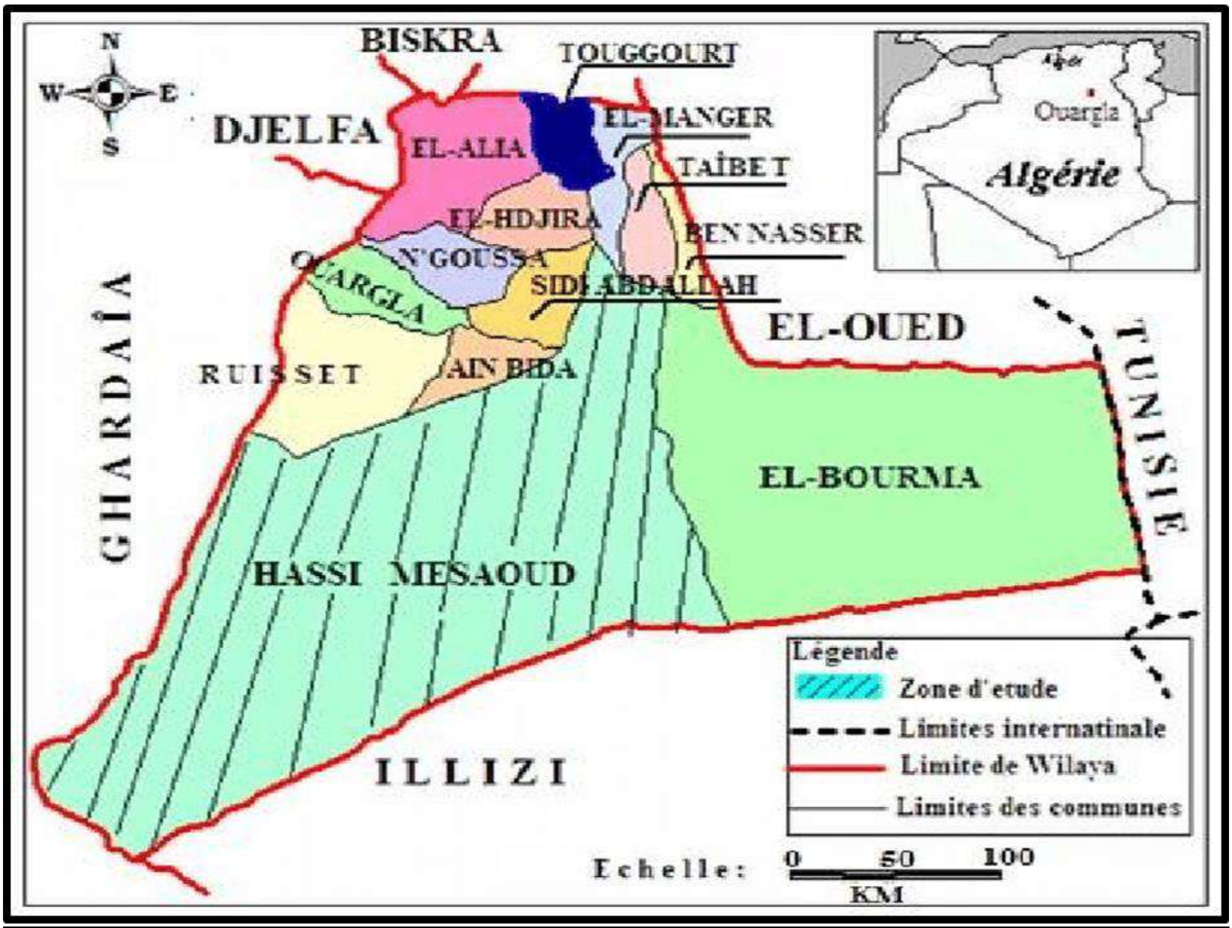

Figure (I.2): HMD geological situation. [1]

I.4.Waters in the oil fields:

During the exploitation of an oil field, with time its necessary pressure decreases, this phenomenon has a direct influence with the production, to recover a maximum oil in the well (secondary recovery), the most used method currently for maintaining pressure this is the injection of water «ALBIEN» in the deposit.

I.4.1. Injection water

Injection water used in secondary oil recovery, Injection of water is one of the means of maintaining reservoir pressure.

Water is one of the means for the removal of salt wells.

- **Washing of salt wells:**
  Some formation waters may contain 350g/1 of sodium chloride and thus be so close to supersaturation that a very small temperature variation or a small evaporation of water due to the fall causing a significant precipitation of
  NaCl on the walls of the tubing until plugging and reduction of the tubing section that leads to the production drop.
  In order to put the wells back into production, we intervene on the NaC1 by simply sending a quantity of fresh water. Whatever its use water injection poses serious problems of incompatibility with reservoir waters. In fact, the reservoir waters may contain Barium, Calcium, and Strontium ions, and be put in contact with the washing water that contains sulfate ions. This results in the formation of depots in plants.
- **Water holding pressure**
  It is used as a means of production when the absolute static pressure at the wellhead decreases rapidly during the operation of a field and the oil recovery in place will only reach a very small percentage of the estimated reserves.

I.4.2. Reservoir water

Deposit water accompanies the crude oil in the producing deposit, this deposit or formation water can come either from the aquifer at the base of the oil deposits or from the rock itself. This water is usually heavily loaded with salts until saturation; the predominant salt is sodium chloride, but it is always accompanied by varying amounts of calcium salt, potassium, magnesium, carbonates, bicarbonates, chlorides… etc.

Indeed, reservoir water sometimes contains a considerable amount of barium strontium and calcium.

Table (I.1): Analysis of different types of reservoir waters. [2]

NAPPES IONS	Mi pliocène	Turonien	Albien	Lias	trias	Cambrien
HCO-3	150	460	170	1370	1710	0
Cl-	1000	119000	420	252510	206380	210000
SO-4	650	1564	550	0	230	0
Ca+2	300	8100	210	116000	388000	36000
Mg+2	100	2500	70	10000	8370	65000
Ba+2	0	0	0	0	0	580
Ma+	450	69840	220	6330	70870	8000
K+	30	1350	0	9240	5190	4500
NH4+	0	0	0	0	0	0
Fe+2	0	0	0	0	0	3750
Fe+3	0	0	0	0	0	0
PH	7.3	6.5	7.3	6	3.5	3.6
D425	1	1.210	1	1.280	1.230	1.232
PF(m)	60-200	780-900	1050-1350	2400-2700	3000-3300	GISEMENT

Chapter II: The diverse organic and inorganic deposit

II.1. Introduction

Organic and inorganic deposits in oil wells are accumulations of organic and mineral matter that can clog production channels and reduce oil and gas production. Organic deposition consists of organic matter, such as oils, fats and organic matter produced by living organisms in the well. Inorganic deposits are formed by minerals such as calcite, gypsum, barite and sulfates, which precipitate when production fluids pass through mineral-rich areas. Inorganic deposits may also contain salts and metals that can corrode equipment and pipes.

Organic and inorganic deposition is a common problem in the oil and gas industry, and can result in a significant decrease in oil and gas production. The management of deposits in oil wells is therefore essential to ensure optimal production and extend the life of wells. Cleaning, treatment and additive techniques can be used to prevent and eliminate organic and inorganic deposits. The classification of deposits according to their composition and origin is important to adapt management techniques to each specific situation.

II.2. the diverse organic and inorganic deposits

II.2.1. Organic Deposits:

Organic deposits in oil wells are accumulations of organic matter that form in casings, production equipment and oil tanks. These deposits can come from several sources, such as sediments, bacteria, algae and marine organisms. Organic deposits can affect oil production and impede fluid flow.

There are several types of organic deposits in oil wells, each with different characteristics and effects on oil production. Some of the most common types of organic deposits in oil wells include:

- **Paraffin deposits:**

  Paraffin deposits, also known as wax deposits, are accumulations of solid organic matter that form in oil wells, pipelines and production equipment. Paraffin deposition consists primarily of paraffins, which are long-chain linear aliphatic hydrocarbons.

  Paraffin deposits form when the oil cools and the paraffins solidify, forming crystals that can adhere to the walls of casings and production equipment. Paraffin deposits can clog casings, pipes and production equipment, reducing oil production and increasing maintenance costs. **[3]**

Figure (II.1) : Paraffin deposition.

- **Asphalt deposits:**

  Asphalt deposits are accumulations of solid organic matter that form in oil wells, pipelines and production equipment due to the precipitation of asphalt from oil. Asphalts are complex organic compounds that contain mainly carbon, hydrogen, nitrogen and Sulphur. These compounds can form colloidal aggregates in oil and precipitate in solid form when physical or chemical conditions change.

  Asphalt deposits can cause production problems in oil wells by clogging casings, pipes and production equipment. Asphalt deposits can also cause oil quality problems by increasing the viscosity of crude oil, making it difficult to transport and process. **[4]**

Figure (II.2): Asphalt deposition.

II.2.2. Mineral deposits:

Mineral deposits in oil wells are accumulations of mineral salts that form in casings, pipes and production equipment due to the presence of production water containing dissolved mineral salts.

Mineral deposits can cause production problems in oil wells by clogging casings, pipes and production equipment, which can result in a decrease in oil pressure and production. Mineral deposits can also cause corrosion problems in production equipment.

Mineral or inorganic deposits consist mainly of:

A. Chlorides:

Chlorides are chemical compounds containing the chloride ion (Cl-). Chlorides are often inorganic salts, such as sodium chloride (NaCl) or calcium chloride ($CaCl_2$). Chlorides can also be organic compounds, such as methyl chloride (CH_3Cl) or vinyl chloride (C_2H_3Cl).

- **Sodium chloride (NaCl):**

  Sodium chloride is an inorganic chemical compound with the formula NaCl. It is soluble in water and occurs as colorless or white crystals.

  Sodium Chloride deposits are one of the common causes of salt deposits that result in a narrowing of the pipe diameter. This problem is caused by the addition of water with a high chloride content which comes naturally with the

  Crude oil, with sodium-laden well waters.

  NaCl is found in greater quantities than the others are, some formation waters may contain up to 340g/l. Very low water evaporation due to the pressure drop causes significant precipitation of sodium chloride.

  This is, however, the least troublesome salt deposit because the solubility of NaCl is large enough that a simple injection of fresh water prevents these deposits from forming.

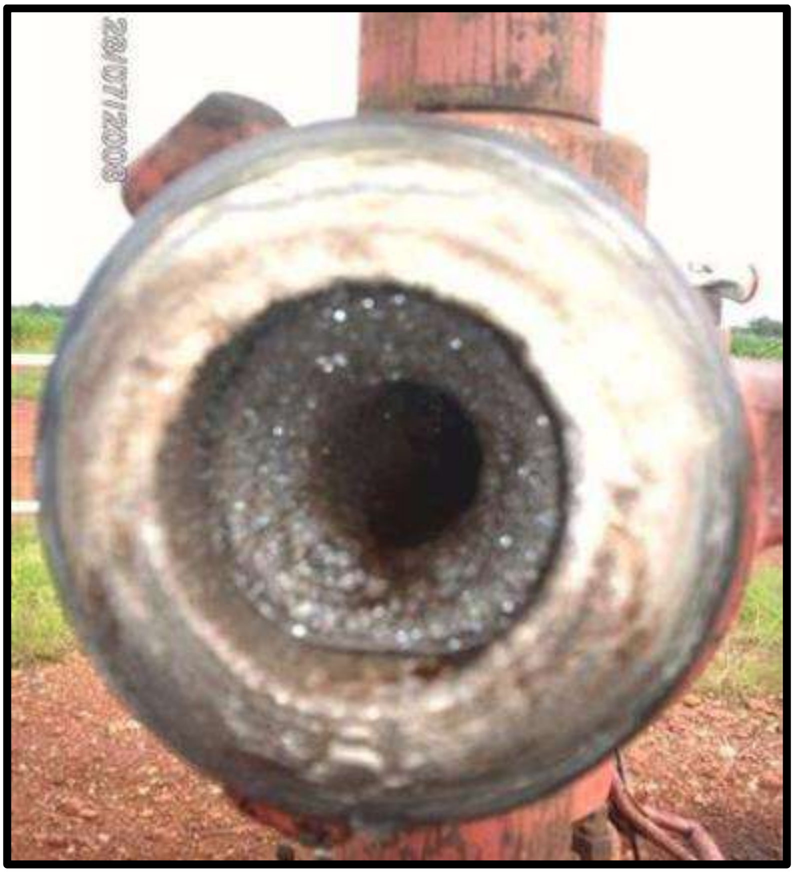

Figure (II.3): NaCl deposit. [5]

B. Carbonates:

Carbonates are chemical compounds containing the carbonate ion (CO_3^{2-}). Carbonates are often found as minerals, such as calcite (calcium carbonate), dolomite (calcium and magnesium carbonate) and siderite (iron carbonate). **[6]**

- **Calcium carbonate ($CaCO_3$):**

These deposits form when the production water contains dissolved calcium carbonate. They can clog pipes and production equipment, resulting in lower oil production. They can also cause corrosion problems in production equipment.

Figure (II.4): Calcium carbonate deposit. [7]

C. Sulfates:

Sulphides are chemical compounds containing the sulphide ion (SO_4^{-2}). Sulphides are often inorganic salts, such as sodium sulphide (Na_2SO_4) or calcium sulphide ($CaSO_4$).

The sulphides come from a mixture of two waters. Deposition is formed at the time of mixing and one of its main characteristics is immediate formation.

Moreover, the main risk is therefore to plug drainage areas or to modify production conditions near the well.

Sulphides deposits are three types:

- **Calcium sulfate ($CaSO_4$):**

Calcium sulfate deposits refer to the accumulation of calcium sulfate crystals ($CaSO_4$) in oil wells, pipes or production equipment. This type of deposition is also called gypsum scale.

Calcium sulfate deposits are often caused by the interaction of formation water, which often contains significant amounts of dissolved calcium sulfate, with production fluids and equipment. Temperature and pressure conditions can also contribute to the formation of these deposits.

Calcium sulfate deposits can reduce the efficiency of oil production by clogging pipes and equipment, reducing fluid flow and increasing pumping pressure.

The combination of (Ca^{2+}) and ($SO4^{-2}$) ions gives the formation of a sulfate calcium precipitate.

Figure (II.5): Calcium sulfate deposit. [7]

- **Strontium sulfate ($SrSO_4$):**

Strontium sulfate deposits refer to the accumulation of strontium sulfate crystals ($SrSO_4$) in oil wells, pipes or production equipment.

Strontium sulfate is often present in formation waters and can be deposited due to evaporation or decreased solubility of strontium sulfate in production fluids.

The deposit of strontium sulfate or Celestine is much less soluble than the Calcium; their solubility decreases with temperature.

Figure (II.6): Strontium sulfate deposit. [7]

- **Barium sulfate ($BaSO_4$):**

Barium sulfate deposits refer to the accumulation of barium sulfate crystals ($BaSO_4$) in oil wells, pipes or production equipment.

Barium sulfate is a very heavy mineral that can reach a density of 4.30 to 4.48 max. Its formation must be avoided because it is the most incrusting and most dangerous deposit among the others because it forms impermeable plugs, clogging, unassailable to acid and bases, its limits of solubility are very low. **[8]**

Then the incompatibility of the two waters, the reservoir water (Cambrian) which contains barium salts and the surface water, which contains sulfate ions (albien) causes the formation of barium sulfate.

Figure (II.7): Barium sulfate deposit.

The mixing of “Albien” waters with “Cambrien” water gives rise to the formation of deposits, the most harmful of which is probably barium sulfate, insoluble even in the presence of strong mineral acids. Reading the results presented in the curve shows that it is possible to obtain BaSO4 deposits with mixtures formed with “Albien” water and “Cambrien” water.

Table (II.1): Evolution of the $BaSO_4$ mass as a function of the Albian water/Cambrian water mixture at ambient T°C.

Mixing rate "Albien" water/ "Cambrien" water (%)	Mass of $BaSO_4$ (mg/l)
16.7 / 83.3	0
33.3 / 66.7	30
50 / 50	90
67.7 / 33.3	205
83.3 / 16.7	450
100 / 0	330
0 / 100	0

II.3. Conclusion

In conclusion, organic and inorganic deposits in oil wells can lead to a variety of production problems that can reduce well efficiency and life. Organic deposition is primarily caused by the formation of paraffin, asphalt and natural gas residues, while inorganic deposition is often composed of mineral salts such as carbonate, chloride and sulfate.

Methods of prevention and treatment of these deposits may include the use of scale inhibiting chemicals, regular cleaning of equipment and pipes, regulation of temperature and pressure conditions in wells, and the application of specific treatments to dissolve or eliminate deposits.

It is important to proactively monitor and manage these deposits to ensure efficient and cost-effective production of oil wells.

Chapter III:

The impact and treatment of deposits

III.1 introduction:

The treatment of deposits is a key topic in the oil industry. Deposits can form in oil wells and pipelines, which can lead to reduced production, downtime, high maintenance costs and premature wear and tear on equipment. Deposits can be organic or mineral, and their composition varies depending on the conditions under which crude oil is produced and transported. Repository processing methods vary depending on the type of repository, the severity of the problem and operational constraints.

III.2 Methods for detecting deposits:

There are several methods for detecting deposits in oil wells. Some of the most common methods are:

- **Chemical analysis:** This involves taking samples of production fluids or deposits for laboratory analysis. The results of the analysis can help identify the compounds present in the deposits and determine the appropriate methods to eliminate them.
- **Thermal imaging:** This method uses thermal cameras to measure temperature variations in surface equipment. Deposition zones can be detected by comparing the temperatures of zones specific to zones with deposition.
- **Regular monitoring:** This method involves monitoring production equipment regularly to detect any signs of deposition. Regular inspections can help quickly identify deposit areas and take steps to eliminate them.
- **Pressure and flow analysis:** This method monitors pressure and flow variations in production equipment. Deposits can result in a decrease in pressure and flow, which can be detected by appropriate monitoring instruments.
- **Radiography techniques:** This method uses X-rays to visualize the interior of production equipment and detect deposits.
- **Electrochemical methods:** This method uses electrodes to measure differences in electrical potential in production equipment. Deposits can create differences in electrical potential, which can be detected by appropriate electrodes.

Depending on the types of deposits and production equipment, different detection methods may be used. It is important to choose the appropriate detection method based on the specific characteristics of the oil well and production equipment.

III.3 Location of deposits:

The location of deposits in oil wells depends on several factors, including the geological and chemical characteristics of the reservoir, the properties of the production fluid, production conditions, temperature and pressure conditions, and properties of production and processing equipment. **[9]**

1) Organic deposits can form in production pipes, valves, pumps and other surface equipment due to the presence of organic compounds such as paraffins, asphalts, resins and oils. Deposition can occur in areas of low temperature and pressure, or in areas where there is a temperature difference between the production fluid and the environment.
2) Inorganic deposits, such as carbonate, chloride, sulfate and silica deposits, can form in areas where the concentration of ions is high, or in areas where there is a difference in temperature or pressure. Mineral deposits can form in areas such as production pipes, surface treatment equipment, heat exchangers and pumps.

III.4 Factors influencing the formation of deposits:

Several factors can influence the formation of organic and inorganic deposits in oil wells. Some of the most common factors are:

1) Chemical composition of production fluids: The chemical composition of the produced fluids can influence the formation of organic and inorganic deposits due to the precipitation of certain compounds such as carbonate, sulfate, paraffin and asphalt. Fluids rich in mineral salts are more likely to form inorganic deposits, while fluids rich in hydrocarbons are more likely to form organic deposits.
2) Temperature and pressure: Temperature and pressure conditions in oil wells can influence the formation of organic and inorganic deposits by affecting the solubility of chemical compounds in production fluids. **[10]**
3) Well life: Well life can also influence the formation of organic and inorganic deposits. Older wells generally have more deposits than newer wells due to the accumulation of debris and reduced efficiency of some maintenance treatments.
4) Nature of reservoir rocks: The nature of reservoir rocks can also influence the formation of organic and inorganic deposits due to chemical interactions between production fluids and reservoir rocks.

III.5. the risks and dangers of deposits:

Deposit formation is one of the most common problems associated with crude oil production.

These problems are summarized in the following points: **[11]**

- **Reduced production flow:** deposits can clog the pores of the reservoir and reduce permeability, limiting production flow.
- **Corrosion:** deposits can promote corrosion of production and transport equipment by creating anaerobic zones where sulfate-reducing bacteria can produce sulfuric acid.
- **Facility clogging:** deposits can form in oil processing facilities, such as storage tanks and pipelines, causing disruptions and production shutdowns.
- **Environmental risks:** deposits can also cause environmental risks, such as soil and groundwater contamination.

III.6. Deposits treatment:

III.6.1 Treatment of organic deposits:

To remedy this problem, which causes a very important economic loss in the oil field, several curative solutions are applied among which: **[12]**

1. **Mechanical scraping treatment**

This method consists of periodically scraping the internal walls of the production tubes by the operation of (Wireline) using a scraper.

However, this operation is sometimes difficult and has disadvantages such as repetition of intervention and breaking of the cable. The treatment is done with scraping and sweeping using the following tools:

- Standard wire-line tools such as: Socket, Jars, Stem and bit.
- Asphalt and paraffin “Cutter” or “Knife”.
- Asphalt and paraffin“Hook”.

Figure (III.1): Mechanical scraping tool.

2. **Chemical treatment:**

In this method, a solvent is injected into the well. Solvents generally used are: reformat, carbon disulfide, benzene, toluene, xylene and chlorinated solvents.

- **Carbon disulfide:**

  It is one of the best solvents, but its use is dangerous. It is toxic, explosive with a flammability point of -22°F (-30°C) and self-ignition temperature 212°F (100°C).
- **Chlorinated solvents:**

  They are excellent solvents, but they damage the catalyst used in the refining process and pose health hazards.
- **Benzene:**

  It is an excellent solvent, but extremely flammable and carcinogenic.
- **Xylene and toluene:**

  They are also excellent solvents. Their saturation point is reached quickly, and they can no longer dissolve.

- **Reformat:**

  It is the most used solvent, it is economical for the treatment of organic deposits in the field of Hassi Massaoude, and it has approved its effectiveness on several wells with good results after treatment. Nevertheless, their use is very dangerous.

3. **Thermal treatment:**

Thermal treatment is a method of treating organic deposits in oil wells that uses heat to remove deposits. This method is used to treat a wide variety of organic deposits, including oils, greases, paraffins and asphalts. Heat treatment techniques include the use of steam, hot water and electromagnetic radiation.

- **Steam treatment:** Steam treatment involves injecting steam into the well to dissolve organic deposits. Steam is injected at high pressure to create a thermal shock that helps break down organic deposits. This method is generally used for organic deposits that are located near the well surface
- **Hot Water Treatment:** Hot water treatment involves injecting hot water into the well to dissolve organic deposits. Hot water can be combined with chemicals to improve treatment efficiency. This method is generally used for organic deposits deeper in the well.
- **Electromagnetic radiation treatment:** Electromagnetic radiation treatment uses electromagnetic waves to dissolve organic deposits. This method is generally used for deep organic deposits in the well. Electromagnetic waves are sent into the well at a specific frequency to dissolve organic deposits.

III.6.2 treatment of mineral deposits

The control of salt deposits consists in removing as much as possible the aqueous phase by a suitable treatment and dissolving the salt crystals in external water.

The existing means of combating salt deposition are:

1. **Cable work (wire-line):**

   The method implements the lightest and fastest means of intervention. The cable working equipment used enables the tubing and bottom equipment to be scraped.

2. **Coiled tubing:**

This operation allows the intervention on the well to be carried out quickly.

This operation involves circulating fresh (or treated) water through the coiled tubing tube into the well, allowing salt deposits and caps to dissolve in the tubing. The operation may take a few minutes, and even hours, depending on the size of the salt cap.

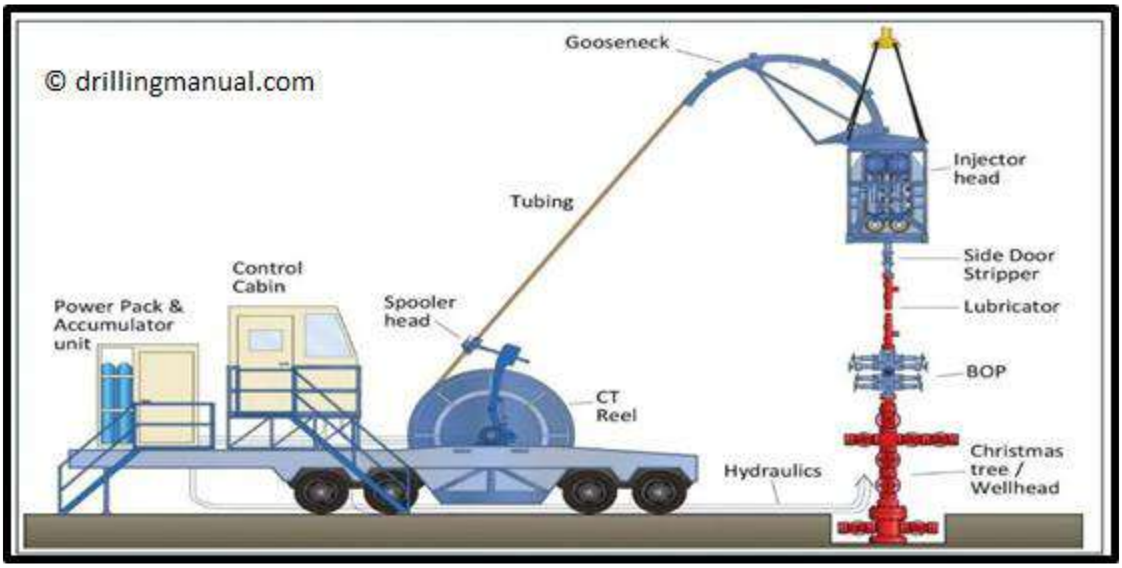

Figure (III.2): Coiled tubing operation.

3. **Injection :**

They are either continuous (preventive objective); or discontinuous (curative objective):

- **Discontinuous injection (periodic) :**

It is a curative treatment of deposits already formed. It does not require any modification of the equipment, but requires interrupting production. The operation consists in sending water plugs to the bottom of the well.

A volume (up to 10 m³ or sometimes more) of treated water (freshwater) is pumped to the wellhead (closed well), while monitoring the head pressure to not drown the well. The cap descends by gravity through the tubing by dissolving with its passage the bridges of salt encountered. It usually pierces the cap after 8 hours. After that, the well is put back into production by disgorging it, by means of the torch, to release it from the water plug.

- **Continuous injection:**

  When accumulations are high. The principle is to pump a small amount of water (the minimum necessary) to the bottom of the well to lower the concentration of the reservoir water.

  This operation has the merit of not interrupting production.

  On low flow wells, water is injected through a small section of pipe down into the production tubing.

  On high-flow wells, water is brought to the bottom of the well through tubing and production is ensured by the annulus.

4. Acid treatment:

Acid treatment is a common method used to remove inorganic deposits, such as carbonates and sulfates, from oil wells. This method uses a strong acid, such as hydrochloric acid (HCl), to dissolve inorganic deposits.

Acid treatment can be performed using a variety of techniques including brushing, injection and acid circulation. **[13]**

- **Acid brushing:** This technique is used to remove inorganic deposits from the well walls by using an acid-impregnated brush that is driven by a cable or winch. This technique is particularly useful for removing inorganic deposits near the well surface.
- **Acid injection:** This technique involves injecting acid into the oil well at a controlled pressure to dissolve inorganic deposits. Acid is typically injected into a specific area of the well where inorganic deposits are most abundant.
- **Acid circulation:** This technique involves injecting and circulating acid through the oil well to dissolve inorganic deposits. The acid is injected into the well at a controlled pressure and then left in contact with the inorganic deposits for a specified period of time. Then the acid is removed from the well using pumps.

Although acid treatment is effective in removing inorganic deposits, it can also present disadvantages such as equipment corrosion, hazardous waste generation, and groundwater reservoir contamination. Therefore, it is important to use this method with caution and take the necessary precautions to minimize the associated risks.

5. **Milling:**

It is done by mechanical partition using scraper, It is used to scrape the walls on which deposited barium sulfate but it can cause cracks at the tubing level during the operation.

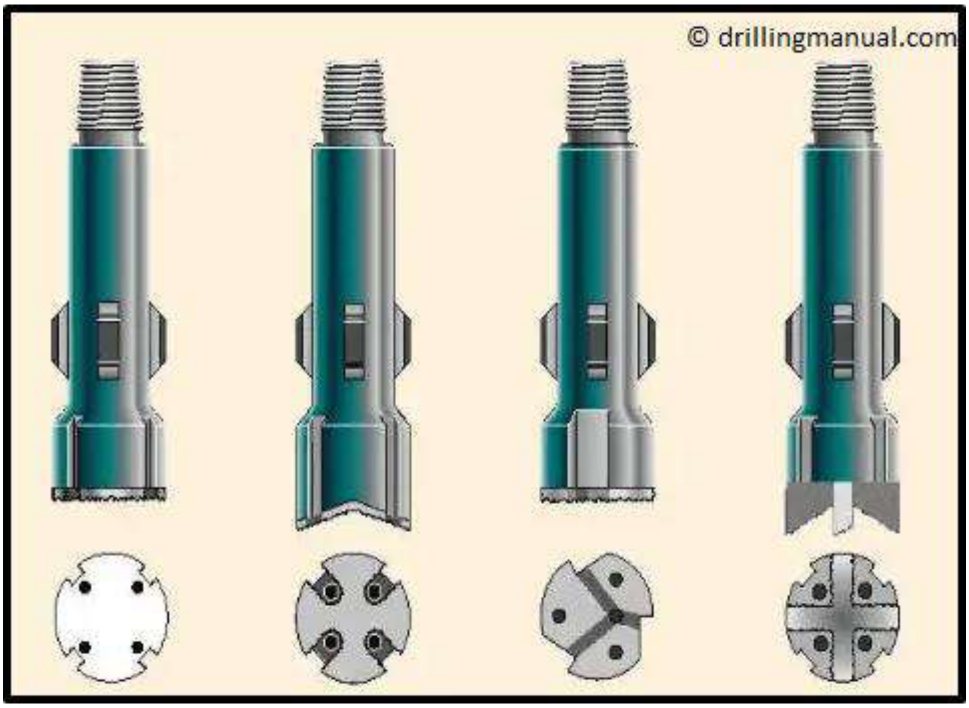

Figure (III.2): Milling operation.

6. **Inhibitor treatment**

Deposition inhibitors are chemicals that are added to the drilling fluid or production fluid to prevent the formation of deposits in oil wells. Inhibitors can be classified into two main categories: precipitation inhibitors and crystallization inhibitors. **[13]**

- **Precipitation inhibitors** prevent the formation of deposits by reducing the solubility of compounds in the production fluid. They function by binding to the ions responsible for the formation of deposits and preventing them from rushing onto the walls of the wells. Precipitation inhibitors are commonly used to prevent the formation of carbonate, sulfate, silica and iron deposits.
- **Crystallization inhibitors** prevent the formation of deposits by inhibiting crystal growth. They function by binding to the crystals that form in the production fluid and

preventing them from developing into deposits. Crystallization inhibitors are commonly used to prevent the formation of paraffin, salt and hydrate deposits.

Inhibitors can be applied in different ways. They can be added directly to the production fluid or drilling fluid, or they can be applied using injection systems. Some inhibitors are specific to one type of deposit, while others are more general and can be used to prevent the formation of several types of deposits.

It is important to note that the effectiveness of inhibitors depends on many factors, such as the composition of the production fluid, temperature and pressure in the well. Case studies and pilot tests are therefore needed to determine the most appropriate inhibitor for each well.

➢ **Type of inhibitors:**

There are many types of deposit inhibitors available on the market. Examples of inhibitors commonly used to prevent deposition in oil wells include:

- **Carbonate inhibitors:** Carbonate inhibitors include acrylic polymers, phosphonates and polyamides. Some examples of commonly used carbonate inhibitors are sodium hydroxyethyl phosphonate (HEDP), ethylene diamine tetra-acetic acid (EDTA) and sulfonated acrylic polymer.
- **Sulfate inhibitors:** Sulfate inhibitors include acrylic polymers, amines, phosphonates and organophosphate compounds. Some examples of commonly used sulfate inhibitors are aminomethylphosphonate (AMP), 2-phosphonobutane-1,2,4-tricarboxylic acid (PBTC) and sulfonated acrylic polymer.
- **Silica inhibitors:** Silica inhibitors include acrylic polymers, phosphonates and silans. Some examples of commonly used silica inhibitors are naphthalene formaldehyde sulfonate (SNF), sulfonated acrylic polymer and triethyl chloride silane.
- **Iron inhibitors:** Iron inhibitors include acrylic polymers and phosphonates. Some examples of commonly used iron inhibitors are sulfonated acrylic polymer and phosphonate of phosphonic acid aminotrimethylene (ATMP).
- **Paraffin inhibitors:** Paraffin inhibitors include polymers, fatty alcohols, esters and amides. Some examples of commonly used paraffin inhibitors are the methyl

ester of fatty acid and methyl diethanolamine (MDEA), acrylic acid polymer and oleic acid.

- **Hydrate inhibitors:** Hydrate inhibitors include glycols, organic salts, polymers and surfactants. Some examples of commonly used hydrate inhibitors are methanol, ethylene glycol, polyvinylpyrrolidone polymer and quaternary ammonium salts.

➢ **Inhibitors utilization:**

Currently the inhibitor used in treatment stations is INIPOL AD 32. They are added to the washing water in order to inhibit the formation of barium sulfate, this inhibitor is not only effective for the formation of barium sulfates but also for carbonates and oxides.

INIPOL AD32 is generally added to production water at very low concentrations, often below 50 ppm (parts per million). It is also compatible with other inhibitors, allowing it to be used in combination with other products for a more complete control of deposits. The benefits of INIPOL AD32 include low toxicity, high efficiency, compatibility with other chemicals and easy use in oil and gas production systems.

The results are satisfactory in view of the decrease in barium sulfate but there are parameters that can influence the desired outcomes:

- Water plugs that are not treated by the anti-deposition.
- The condition of BSB pumps.
- Leaks caused by corrosion of lines.
- repeated disturbances in water flow that cause:
- Overdoses in treatment product in case of decrease in water flow.
- Dilutions of the treatment product in case of increased water flow.

III.7 Conclusion:

In conclusion, deposits in oil wells can cause significant production problems and can cause significant financial losses for oil companies.

Fortunately, there are several effective deposition treatment methods to prevent their formation and reduce their impacts on oil and gas production. Treatment methods include the use of inhibitors, heat treatments, acid treatments and mechanical treatments. Each treatment method has its advantages and disadvantages, and it is important to select the appropriate method according to the production conditions and the types of deposits that form.

Preventive treatment of deposits is also important and involves practices such as oil and gas production management, water quality control, regular monitoring of wells and the use of inhibitors from the beginning of production. By applying preventive treatment practices and using effective treatment methods, oil companies can minimize the risks and impacts of deposits on oil and gas production.

CHAPTER IV:

STATISTICAL AND EXPERIMENTAL STUDY

IV.1 Introduction

Organic and inorganic deposits in oil wells are a common problem for oil and gas companies, resulting in production disruptions, high maintenance costs, and reduced quality of oil and gas produced. To better understand the frequency and severity of these deposits, statistical and experimental studies are conducted to analyze the production and exploitation data of many oil wells.

These statistical studies are generally based on long-term production and exploitation data for many wells, and identify factors that contribute to the formation of organic and inorganic deposits.

IV.2.Part A

A.1. Deposit analysis results

The deposits collected during the intervention on wells and installations of production on HMD field are analyzed at the laboratory to know their compositions and determine their natures: organic, mineral, formation etc.

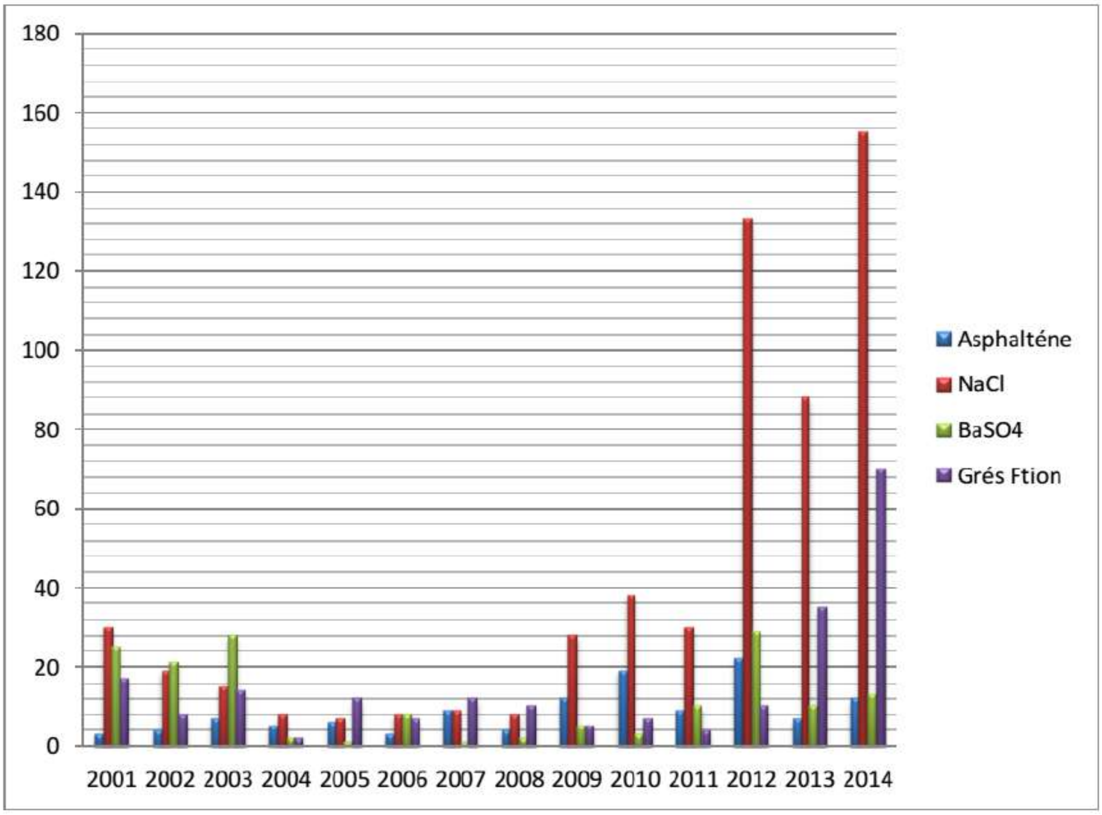

Figure (IV.1): deposit analysis results.

A.2. Well Selection:

The following histograms represent the most common deposits in the HMD fields, following the results. The following histograms represent the most frequent deposits in the HMD field. Following the results, we find that the **MD411** well has mineral deposits (barium sulfates BaSO4and NaCl salts) and **RDC09** has organic deposits (Asphalts), for this, a modest statistical study on these wells are made in order to test the best methods of minimization and treatment of these deposits.

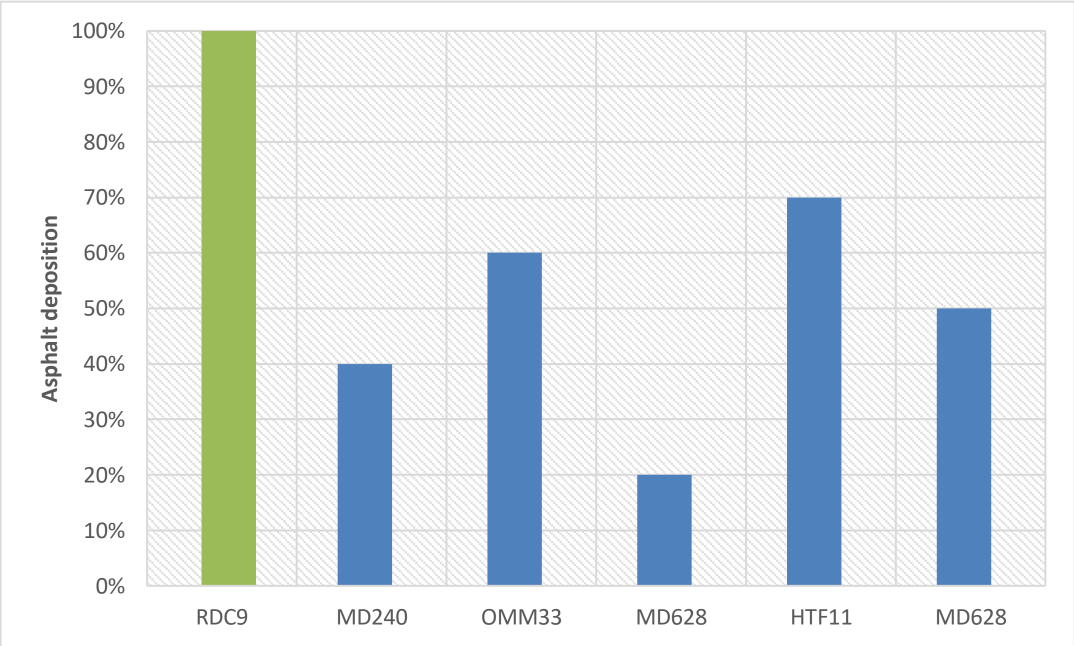

Figure (IV.2): Asphalt deposition in several wells.

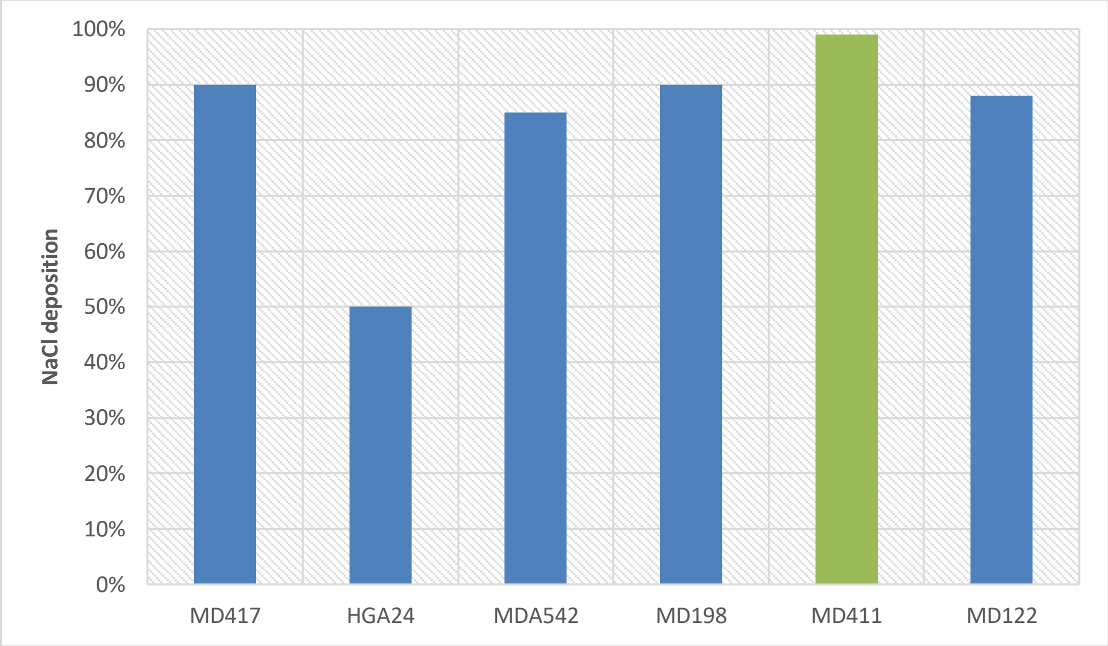

Figure (IV.3): NaCl deposition in several wells.

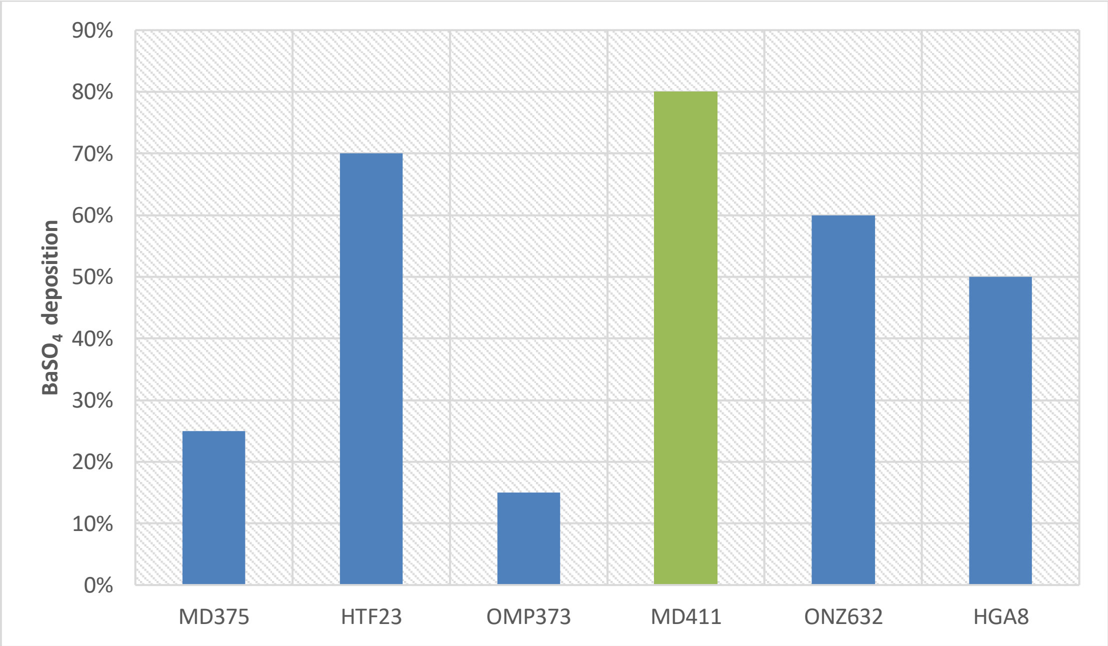

Figure (IV.4): Barium sulfate deposition in several wells.

A.2.1.Well MD411:

Well History:

The MD411 well is an oil producing well drilled in 23/01/1987. Is located in the northwest of Hassi Messaoud. **[14]**

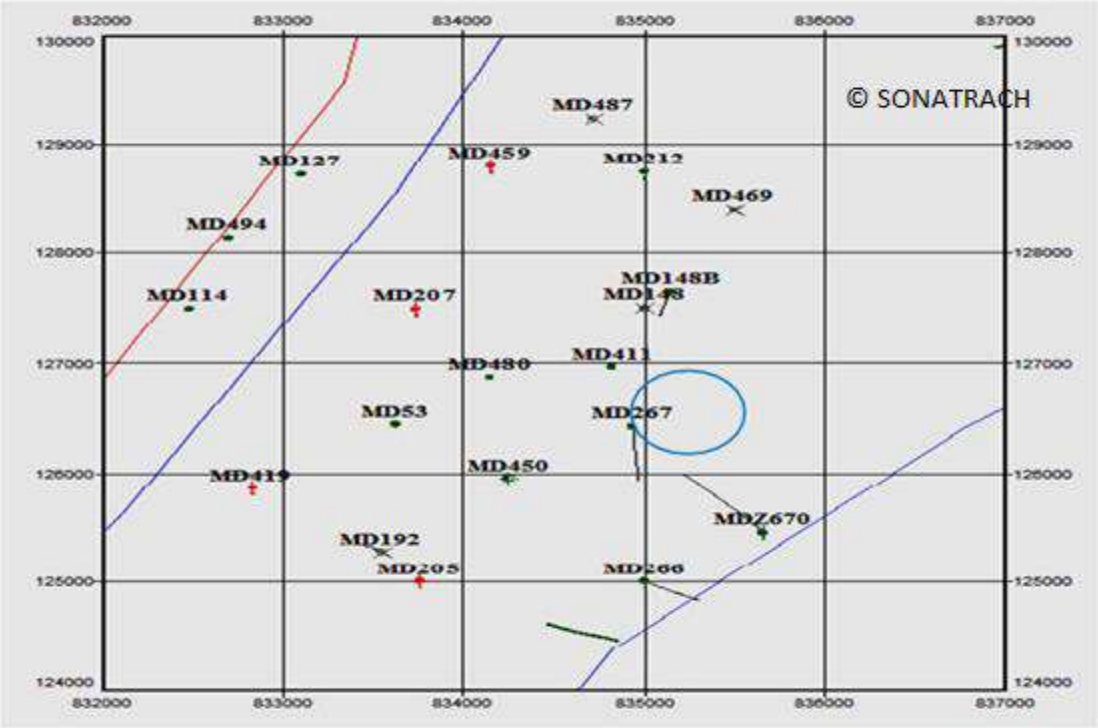

Figure (IV.5): Well MD411 location.

Well problem:

The well MD411 is known for the problems of BaSo4 barium sulfate deposits and NaCl salts, which are the causes of the frequent plugging of the tubing that generated a drop in well production.

- To have a better understanding of the well problems we analyze the measurement test:
  - **Measurement test:**

The main purpose of this test is to measure the production rate, but this test allowed us to obtain other parameters characterizing crude oil such as GOR, oil temperature and water salinity.

Table (IV.1): Measurement test results.

Measurement date	Duse (mm)	Q Oil (m3/h)
01/2020	22	**8.2**
04/2020	22	**7.75**
07/2020	22	**7.80**
10/2020	22	**7.60**
01/2021	22	**4.23**
04/2021	22	**8.2**
07/2021	22	**5.6**

- **According to the measurement test results, we can mention the following interpretations :**
  - A decrease from **7.60 m3/h** to **4.23 m3/h** caused by the mineral deposition in the well.
- The consequences of this problem are as follows:
  - Loss of production.
  - Increased well response frequency and outages.
  - Increase in operating expenses.
  - Clamping Wire Line tools and coiled tubing inside the well.
  - An increase from **4.23 m3/h** to **8.2 m3/h** caused by the special operations used to minimize the mineral deposition in the well.
- The operations used are:
  - Chemical treatment by cleaning and acid squeeze.
  - The mechanical operation by scale Blaster.

1.1 Well MD411 Treatment:

- To avoid or remove NaCl deposition injection water is used periodically, which requires interrupting production (curative) or continuous (preventive) without stopping production.
- To avoid BaSO4 deposit problems, a deposit inhibitor is added to the injection water to create an interface between the injection water and the reservoir water. The most used inhibitor is INIPOL AD32.

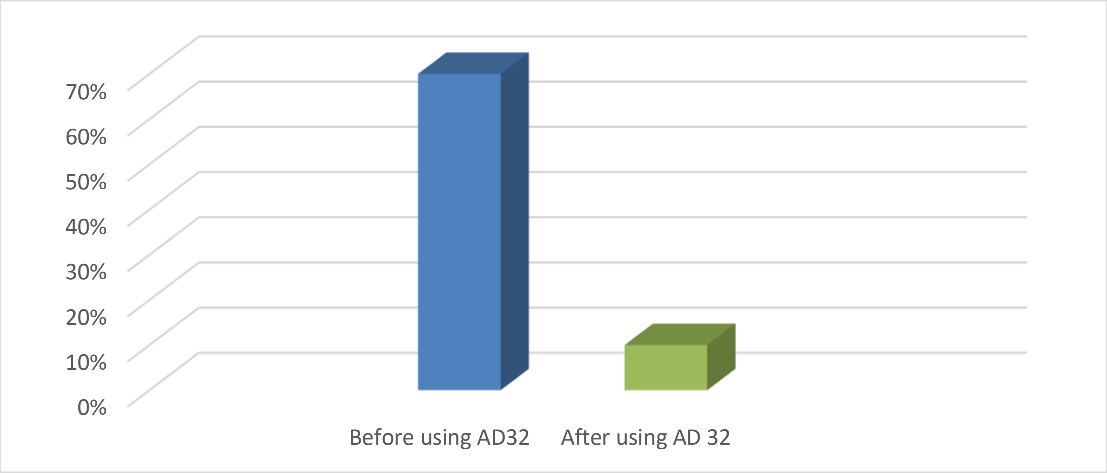

Figure (IV.6): analysis of barium sulfate deposition before and after the usage of inhibitor AD32.

- To remove BaSO4 deposit problems. We use a mechanical treatment (Milling, Scale blaster) that last from 01 to 02 months resulting in more production stoppages.

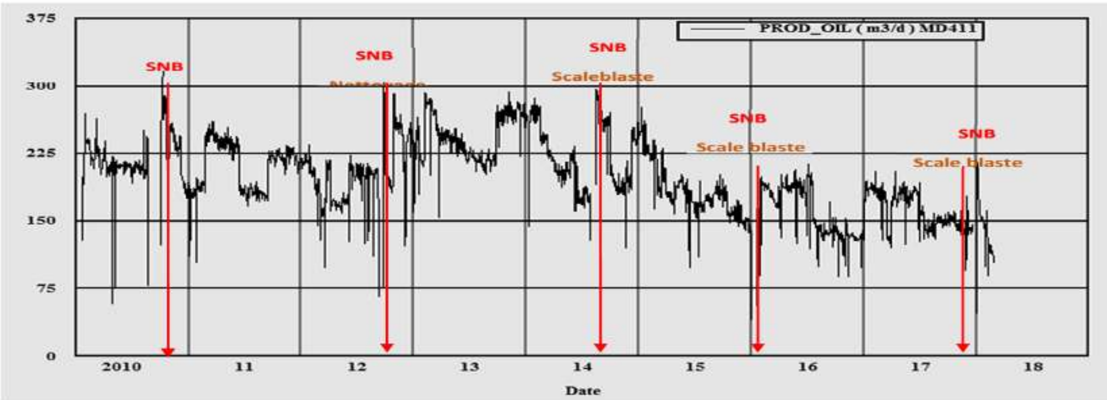

Figure (IV.7): Analysis of well production before and after mechanical treatment.

A.2.2.Well RDC 9:

Well History:

RDC9 is a vertical well; oil producer, drilled on 01/10/2008. **[15]**

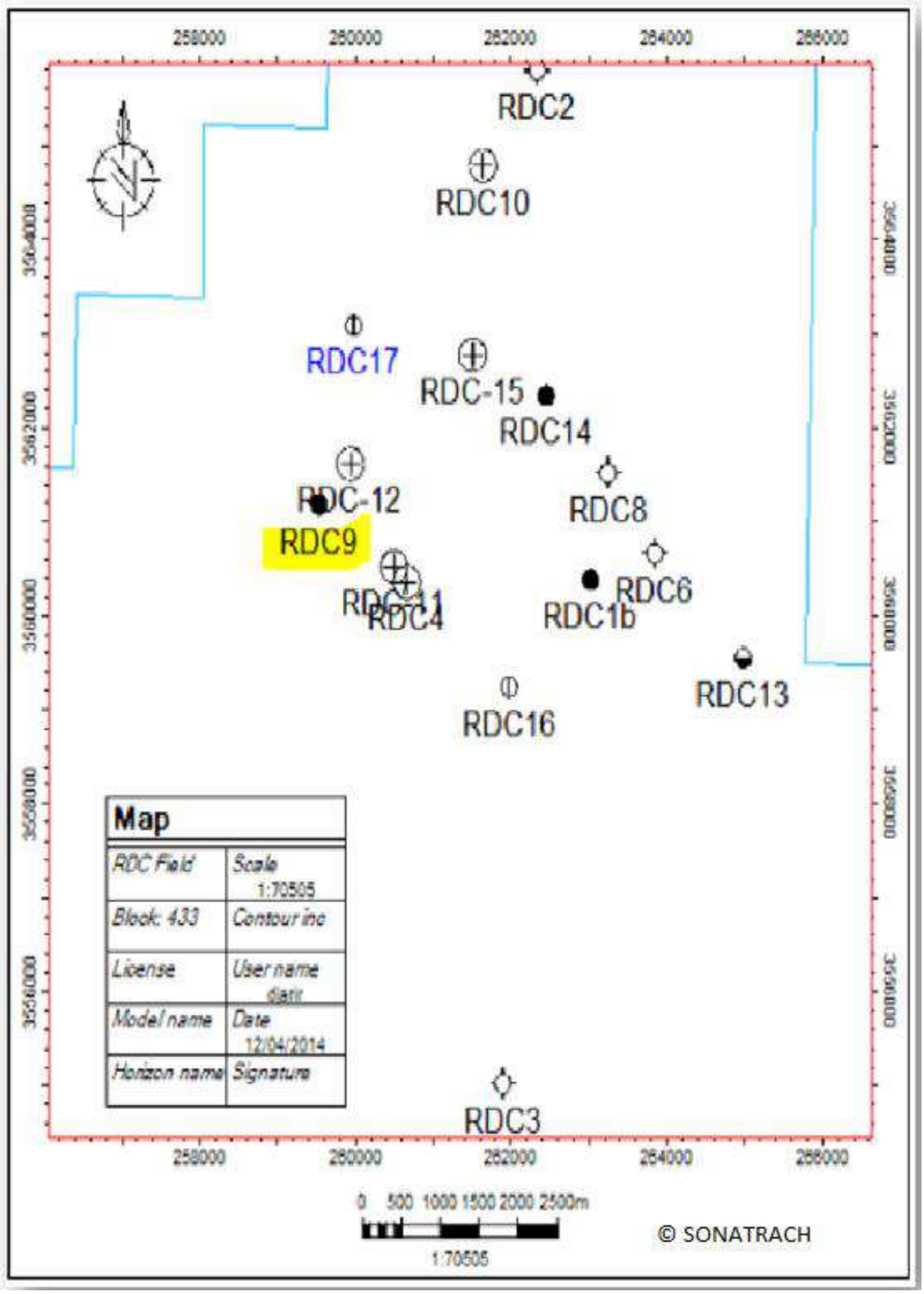

Figure (IV.8): Well RDC9 location.

Well problem:

Damage may be due to asphalt deposits.

➢ To have a better understanding of the well problems we look at the measurement test:

- **Measurement test:**

The main purpose of this test is to measure the production rate, but this test allowed us to obtain other parameters characterizing crude oil such as GOR, oil temperature and water salinity.

Table (IV.2): Measurement test results.

Measurement date	Duse (mm)	Q Oil (m3/h)
01/2020	22	**8.31**
04/2020	22	**8.29**
07/2020	22	**8.24**
10/2020	22	**5.12**
01/2021	22	**8.22**
04/2021	22	**5.61**

➢ **According to the measurement test results, we can mention the following interpretations :**

- A decrease from **8.24 m3/h to 5.12 m3/h** caused by the asphalt deposition in the well.
- The consequences of this problem are as follows:

- Loss of production.
- Increased well response frequency and outages.
- Increase in operating expenses.
- Clamping Wire Line tools and coiled tubing inside the well.

- An increase from **4.23 m3/h to 8.2 m3/h** caused by the special operations used to minimize the asphalt deposition in the well.

Well RDC9 Treatment:

To maintain RDC9 well productivity and remove organic deposition in the tube that restricts effluent flow, the following action is used:

- Injecting solvents in the well. The most used solvent is REFORMAT, other solvents like XYLEN or TOLUENE are considered better solvents but REFORMAT is more economic.

➢ **Note:**

- Mechanical treatment can be used to remove asphalt deposition but it is not preferred because it costs more and requires longer production stoppages.

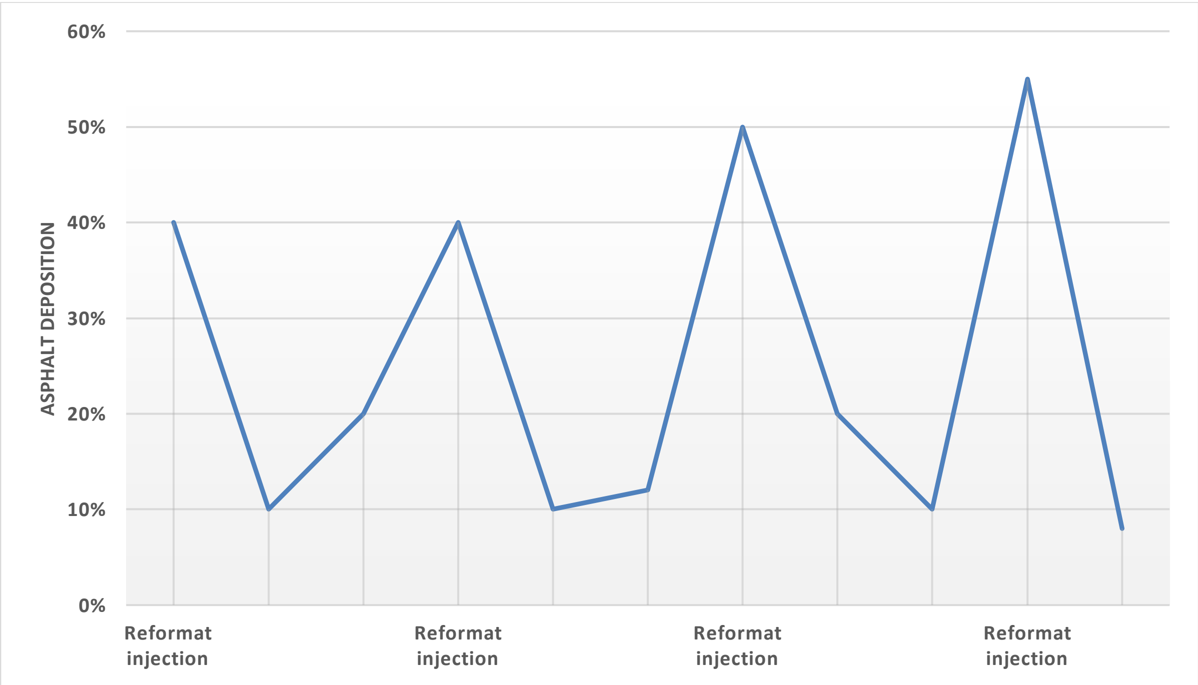

Figure (IV.9): Analysis of asphalt deposition after reformat injection.

IV.3.Part B

B.1. Experiment objectives:

The purpose of this study is to determine which chemical compound is the best organic deposition solvent.

- ***Note:*** *we have not used mineral deposition such as barium sulfate because of its very low solubility rate.*

B.2. Material and methods:

B.2.1 Material:

The materials used in this experiment are as follows:

- **Organic deposition:** a composition of 87% asphalt and 13% paraffin.

Figure (IV.10): Organic deposition.

- **The solvents:** benzene, toluene, xylene and heptane were used in this experiment.

Figure (IV.11): Solvents.

- **The glassware:** beakers 250 ml.

Figure (IV.12): 250 ml beaker.

B.2.2. Methods:

2g of the organic deposition is dispersed in 10ml of each solvent for a period of 24 hours.

Figure (IV.13): experiment samples.

B.3. Results and discussion:

After 24h, we can mention the following interpretations:

- Xylene is the best solvent.

Figure (IV.14): Xylene sample.

- Heptane is the worst solvent.

Figure (IV.15): Heptane sample.

IV.4 Conclusion:

In conclusion, the statistical study of organic and inorganic deposits in oil wells is an essential approach to understanding the nature, extent and characteristics of deposits in these facilities. Deposits can cause production disruptions and high operating costs, hence the importance of minimizing them.

The use of statistical techniques to collect, analyze and interpret data on deposits in wells provides valuable information on the frequency, gravity, spatial and temporal distribution of deposits. This information can be used to develop appropriate prevention and treatment strategies based on sound scientific evidence.

The statistical study of deposits in two oil wells can make it possible to compare and evaluate the differences and similarities between deposits in different installations, thus contributing to the understanding of the factors influencing their formation. The results of the statistical study can also be used as a basis for informed decisions on best management practices to minimize deposits in oil wells.

In short, the statistical study of organic and inorganic deposits in oil wells is a valuable tool for understanding and minimizing these problems, thus contributing to more efficient and cost-effective oil and gas production.

GENERAL CONCLUSION

Minimization of organic and inorganic deposits in oil field wells is a crucial issue to ensure efficient and cost-effective oil and gas production. Deposits can lead to production disruptions, high operating costs, and safety and environmental risks. Thus, effective management of these deposits is essential to optimize well performance and maximize oil recovery.

The study of the memory of minimization of deposits in two oil field wells, using statistical methods, allows collecting and analyzing data on the frequency, the gravity, the spatial and temporal distribution of deposits. This information can be used to develop specific prevention and treatment strategies, tailored to the characteristics of wells and deposits.

Inhibitors, thermal treatments, chemical methods and preventive approaches are commonly used to minimize organic and inorganic deposition in oil field wells. However, each technique has its advantages and disadvantages, and it is important to choose the appropriate method according to the specific conditions of the oil field, the types of deposits and the production objectives.

By integrating the results of the study of deposit minimization memory into oil field well management practices, it is possible to put in place effective strategies to minimize the formation and accumulation of deposits, reduce operating costs, improve well performance and optimize oil recovery.

In short, the minimization of organic and inorganic deposits in oil field wells is a major challenge for the oil industry, and the study of the memory of minimization of deposits, associated with the use of appropriate prevention and treatment techniques, ensures optimal and sustainable oil and gas production.

Based on the findings of this research, the following recommendations are provided to promote the adoption of several methods of minimizing deposition in oil wells like chelating agents which are more environmentally friendly and less corrosive and more diverse scale inhibitors

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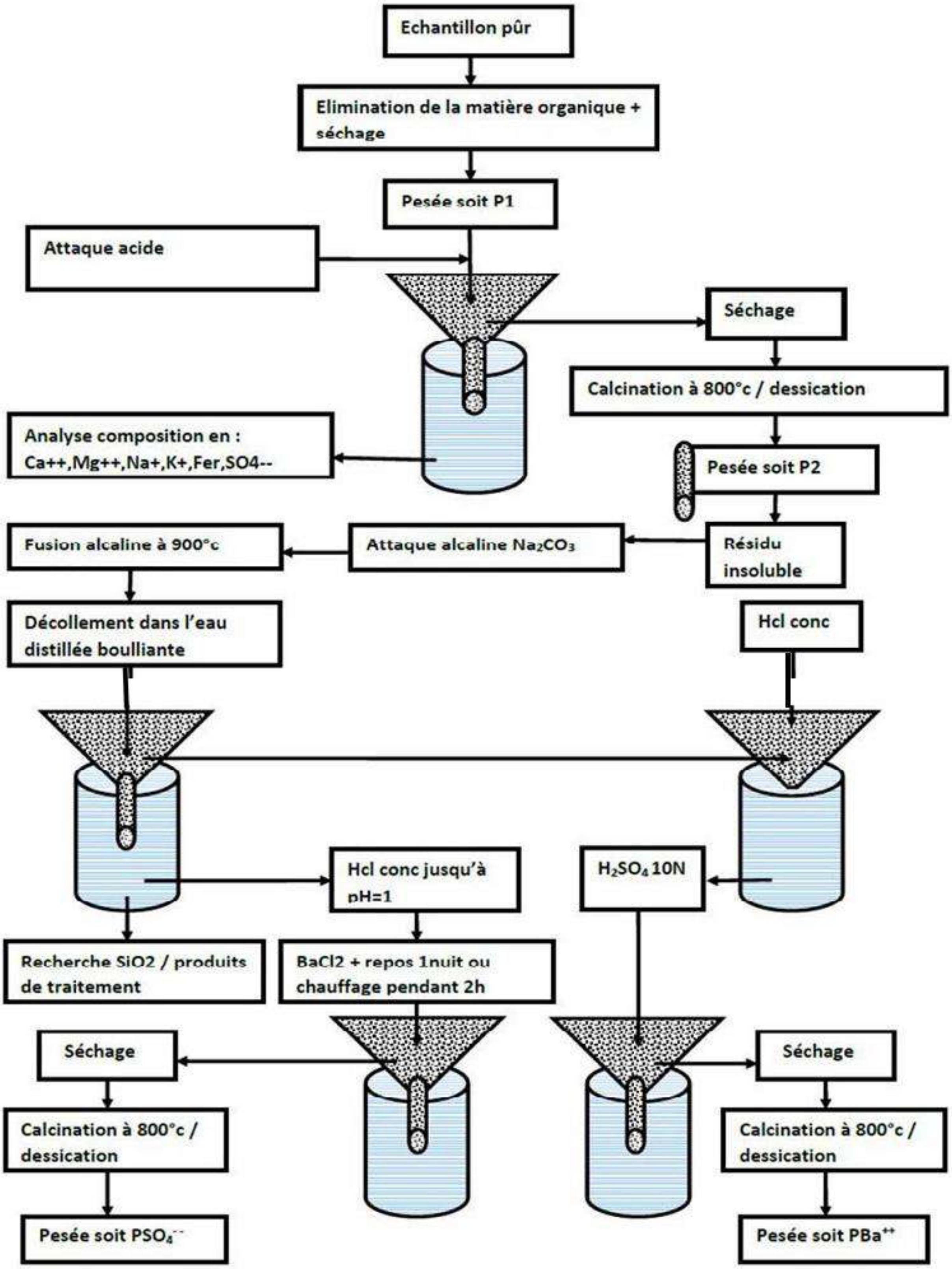
ANNEXES



<u>**General scheme of quantitative analysis of a deposit.**</u>

Mineral deposit analysis method:

A/Acid attack:

Once the sample is dried and ground, the acid attack is carried out, a test sample of 1 g is dissolved in 60 ml of water (40 ml of HCl +20 ml of HNO_3) completely evaporate the solution on a heating plate the operation takes about 2 hours.

Dissolve the residue in 20 ml of HCl and evaporate dry, add 10 ml of distilled water and dissolve the precipitate by boiling for 1mn.

Repeat the previous operation by adding 20 ml of water and a 10mn boil, then 100ml of distilled water and a 15mn boil, then filter.

After filtration the precipitate is kept and the filtrate is reduced to a volume of 250 ml, to measure calcium, magnesium, iron, sulfates, phosphates, sulphides, sodium, etc. Either by the volumetric method or by using the spectrophotometer.

B/Alkaline Attack:

The insoluble residue obtained during the acid attack is recovered and then calcined in the 800°C muffle oven in a platinum crucible. Weigh the crucible contents and add about 5-6 g of sodium carbonate. Melt in the muffle at 900°C for 30'. Remove the crucible and let cool with the desiccator. Meanwhile, boil about 200 cc of distilled water in a beaker. After cooling the crucible, place the crucible in the beaker and boil until it comes off.

In this way, silica, sodium sulfate and barium carbonate are obtained in the filtrate. Dissolve the contents with Hcl, recover in a 250 ml beaker. Spread with distilled water and boil. After boiling add H2SO4 10 N. A white precipitate forms energetically which indicates the presence of barium sulfate. Let stand overnight then filter, wash, dry, and calcine in the oven at 800°C.

Let P2 be the weight of the precipitate obtained:

% BaSO4 = P2 x 100.

% SiSO2 = (P1 - P2) x 100.

Organic deposit analysis method:

The sample dried in the oven at a temperature of 150° to 200° for about 2 hours is ground in a porcelain mortar. Take 5g from a previously dried porcelain basket and weigh it with an analytical scale.

The deposit will then be calcined in an 800° muffle oven for 1 hour, the basket is cooled in a desiccator and weighed.

Either:

p: the test portion.

nv: weight of the empty basket

nc: weight of nacelle after calcination.

The percentage of organic matter is:

$$\% \, M.org = (p-(nc-nv)).\ 100/p$$