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Emirates International University
Engineering and IT Faculty
Dep _ Oil and Gas Engineering

الجمهورية اليمنية
الجامعة الاماراتية الدولية
كلية الهندسة وتقنية المعلومات
قسم هندسه النفط والغاز

EMIRATE INERNATIONAL UNIVERSITY

FACULIY OF ENGINEEERING AN INFORMATION TECHNOLOGY

OIL AND GA ENGINEERING DEPARTMENT

PERFORMANCE EVALUATION OF THE FIELD AND DIAGNOSES EXCESSIVE WATER PRODUCTION FROM SHARYOOF FIELD (BLOCK 53)

A PROJECT SUBMITTED IN PARTIAL FUFILLMENT

OF THE REQUIREMENTS FOR THE DEGREE

OF BACHELOR OF SCIENCEIN OIL

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BY:

ABDULLAH AL-ZOBA

- FAIZ AL-SARETI
- ABDULLRAHMAN
- RAMZY FADEL
- JOBRAN JRAWSH

AHMED AL-SHIBLY

SUPERVISOR

DR YASIN SALEH

SANA'A

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DECLARATION

We Hereby declare that this project report is the record of authentic work carried out by us and has not been sub ted to any other university or institute for the award of any degree / diploma etc .

APPROVAL

This is to certify that the project titled **performance Evaluation of the field and Diagnoses Excessive Water Production in Sharyoof Oil Filed (Block 53)** has been read and approved for meeting part of the requirements and regulations governing the award of the Bachelor of Engineering (Oil and Gas) degree of Emirates. International University, Sana'a, Yemen.

Project Supervisor**: *DR. Yasin Al-Salehi*** Date: ……………………

Signature: …………………

Abstract

Excessive water production is one of the major problems in Yemenis oil fields. The main purpose of this project is to diagnose the excessive water production mechanisms as case of a Sharyoof oil field.The Production history plot evaluate production performance during all time of production. The diagnostic plots derivative method is applied using Oil Field Manager program on calculating and plotting the derivative response to understand the mechanisms that create the problem, considering three examples of a Yemenis oil well's data. As a result of this research, water channeling is the main reason for water production in three wells, and conning has important effect in increase water production.

ACKNOWLEDGMENTS

First of all, we owe our most sincere gratitude to Allah the almighty and the most powerful for offering us such a strength, endurance, willingness, and capability to accomplish this project.

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List of Symbols and Abbreviation

DNO	Distribution network operator
WOR	water/oil ratio
WPM	water production mechanism
FPP	formation parting pressure
PAM	Polyacrylamide
HPAM	hydrolyzed polyacrylamide
OFM	OIL FIELD MANAGER
OD	Out diameter
ESP	Electric submersible pump

1.1 Introduction

Excessive water production is one of the common and challenging problems associated with hydrocarbon production. Reservoir rocks normally contain both petroleum hydrocarbons and connate water. Once the production starts, this water called connate water is also produced into the wellbore comingled with oil. In addition to the connate water contained in reservoir rocks, many petroleum reservoirs are bounded by or are adjacent to large aquifers. These aquifers can provide the natural drive for petroleum production. Once the aquifer pressure is depleted, additional water is also injected into the reservoir to provide further pressure to the hydrocarbon reserves to move towards the production wells. Water from these various sources can flow into the wellbore and co-produced with the hydrocarbon stream. Such water is referred to as produced water. The ratio of produced water to the produced oil is denoted as WOR (water/oil ratio). The WOR economic limit is where the cost of handling and disposal of the produced water approaches the value of the produced oil. The water produced in to the well bore comingled with oil at an economic water/oil (WOR) ratio is an accepted fact in the oil industry as it cannot be reduced or shut off without affecting the oil production. Problems arise when water flows in to the oil well at a rate exceeding the economic WOR limit, producing little or no oil.The cost of handling and disposing this unwanted water could have a negative impact on the economic life of the oil well. It is estimated that on average oil companies produce three barrels of water for each barrel of oil, which entails a staggering cost of US$ 30-40 billion worldwide . In addition to the direct cost of handling the produced water, it also has negative impacts on the overall productivity rates. Excessive water production reduces the net oil production rate, increases corrosion rates in the production system and may eventually lead to early abandonment of the affected wells. The environmental issues in connection with water production are another concern for oil companies. They have to comply with strict environmental regulations regarding water treatment and disposal facilities, which consequently increases production costs. Water is produced in to the well due to many different causes. Water production can be related to mechanical problems, poor completion procedures or reservoir conditions. The main obstacle in the management of water production studies is the correct diagnosis of the nature and the origin of the problems. Each problem type requires a different approach to control and treat the problem effectively. In reality, an oil well can experience a combination of different problem types. However, reservoir related problems of coning and channelling through high permeability layers are more challenging to diagnose and treat. The mechanism and the volume of the water produced into a wellbore mainly depends on petrophysical properties, pressure and temperature conditions of the reservoir, geometry and conditions of the aquifers, trajectory and location of the drilled wells within reservoir structure, type of completion and stimulation methods. Depending on the characteristics of the reservoir, type of the diagnosed problem and objectives of the water production treatment, a variety of mechanical, chemical and well construction techniques can be applied to stop or reduce the flow of water into the wellbore. However, the water production mechanism (WPM) must be properly investigated and accurately diagnosed in order to design an appropriate and effective treatment method. Incorrect, inadequate, or lack of proper diagnosis usually leads to ineffective water control treatments. Several analytical and empirical techniques using information such as production data, water/oil ratio and logging measurements have been developed to determine the type of water production problem, locating the water entry point in the well and choosing the candidate wells to perform treatment methods. Water/oil ratio diagnostic plots are probably the most widely used technique in reservoir performance studies. Many oil companies to date rely on log/log plots of WOR and its derivative against time to identify WPMs caused by water coning or channeling.

1.2.Geology of Yemen

Yemen, officially known as the Republic of Yemen, is an Arab country in Western Asia, occupying South Arabia, the southern end of the Arabian Peninsula. Yemen is the second-largest country in the peninsula, occupying 555000 sq km . The coastline stretches for about 2,200 km. It is bordered by Saudi Arabia to the north, the Red Sea to the west, the Gulf of Aden and Arabian Sea to the south, and Oman to the east.

The country of Yemen is in the Asia continent and the latitude and longitude for the .country are 12° - 18° N, 42°- 53° E

Sedimentary basins of Yemen and their classification according to the geologic area in which they formed.

Paleozoic basins:

1. Rub‟ Al-Khali (the southern flank of a much larger basin extending into Saudi Arabia.

2.Sana'a.

3. Suqatra (an island in the Gulf of Aden).

Mesozoic basins

4 .Siham-Ad-Dali .

5 .Sab‟atayn .

6.Say‟un-Masilah .

7. Balhaf .

8. Jiza‟-Qamar .

Cenozoic basins:

9. Mukalla-Sayhut .

10 .Hawrah-Ahwar.

11 .Aden-Abyan .

12.Tihamah [Journal Of GEO_ExPro_V13i2] .

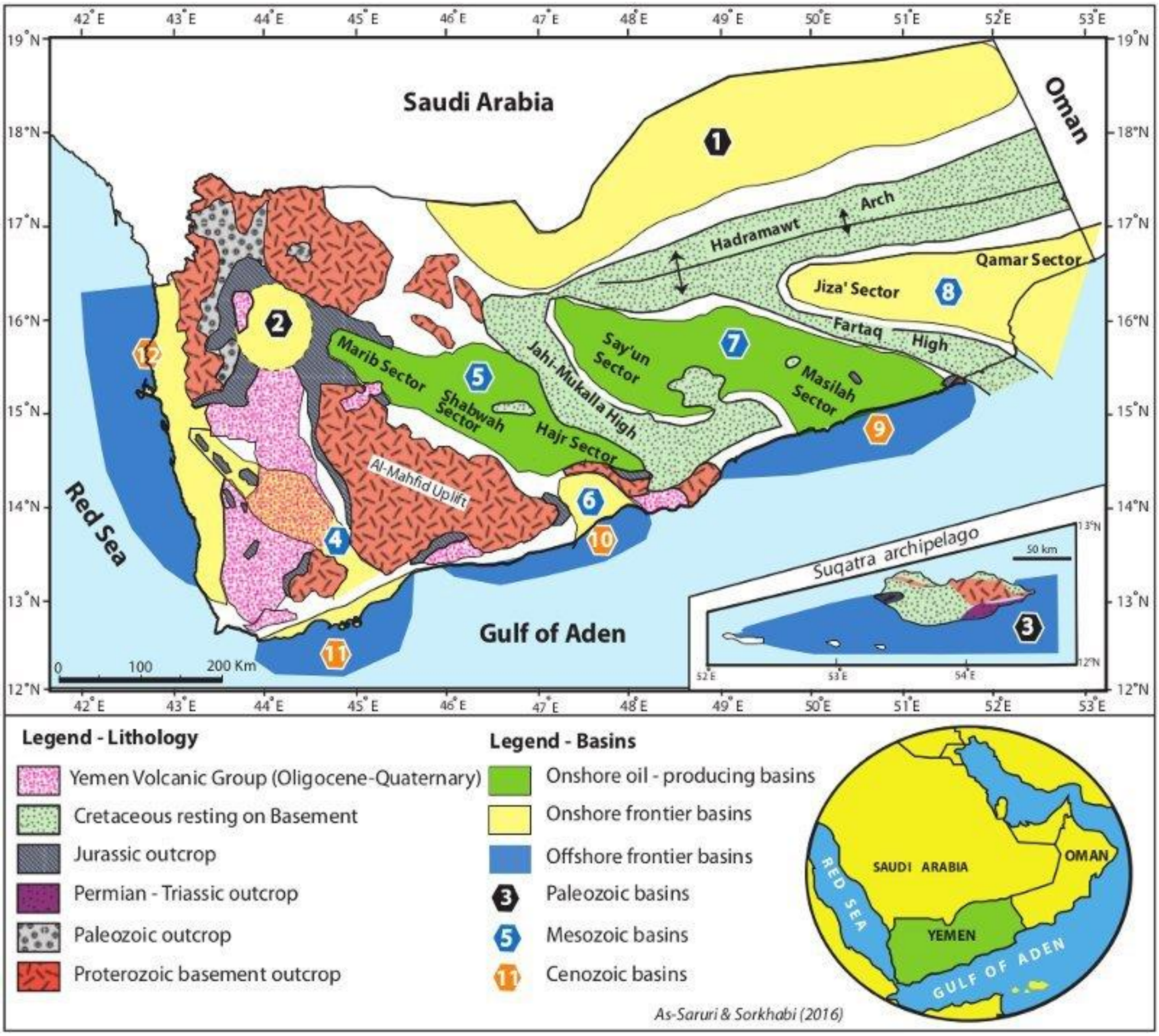


Figure.1.1 sedimentary basins of Yemen and their classification

1.2.1 Stratigraphy of Yemen:

1. 2.1.1 Paleozoic area:

Wajid Formation:

The Wajid Sandstone, of probable Early Paleozoic age, rests non conformably on crystalline rocks of the southern part of the Arabian shield and considered the oldest formation in the region. The Wajid Sandstone is extensively described from southern Saudi Arabia, because it is widely exposed there. Wajid sandstone deposits from Saudi Arabia into northern Yemen cover a wide area north of Sa'dah and east and north of AlJawf area. The southern boundary east of Al-Jawf province is a fault while some remnant hills exist in small isolated grabens west of the Sa'dah depression. No specific reference section was selected but in Jabal Dal'an, north of Sa'dah, the formation exceeds 200m in thickness.

Akbarah Formation:

Akbarah formation (Late Carboniferous-Permian): tillite (pebbles & boulders of basement rocks), shales, mudstones, sandstones and siltstones. At the Kuhlan Village section, the Akbarah Formation is in two parts. The lower part is composed of thick sandstone beds fining upwards to siltstone and thick fissile shale. These units are interbedded with massive and stratified diamictite beds.The upper part is composed of several cycles beginning with beds of thin, fine-grained sandstone fining upwards to thick fissile shale beds, interpreted to be of marine origin (Stephenson & Kader AlMashaikie, 2011). The depositional environment of the Akbarah Shale is thought to be lacustrine or fluvio-glacial.

1.2.1.2 Mesozoic area.

Kuhlan Formation:

In early to mid-Jurassic time sandstone was deposited widely across Yemen, where thick sedimentation developed in lows formed before Jurassic time. It is a transgressive clastic sequence found throughout the basin as localized erosional remnants this thick sandstone deposit is known as the Kuhlan Formation and it is composed of siltstone and sandstone to conglomerate with some streaks of limestone and green clay. In Masila oil fields the sandstone of the Kuhlan Formation is very fine to medium grained, well sorted with good to poor porosity. Sediments within the Kuhlan Formation were deposited during the transgression of the sea over the exposed and eroded igneous and metamorphic basement complex. Clastic sediments in this unit were deposited by subaerial to shallow water, near shore processes.

Shuqra Formation: (Amran Group).

This formation was considered as representing a part from the Jurassic outcrops and had been referenced to as “Amran Series” by (1925) and Lamare (1930). The recorded type section of this formation was measured by Wetzel and Morton (1950) at Jabal Urays and lies at a distance 15 km N17°E of Shuqra City which is located on the Coast of Aden Gulf. They measured 98m of dark gray well-bedded limestone. It is Lithological composed of carbonate marl/shale, and depositional environment is shallow marine of the platform and of pre-rift areas. Formation is exposed in wide geographic areas in the northern, western, and southern parts of Yemen with variable thickness due to erosion.

Madbi Formation: (Amran Group).

The age of Madbi formation can be regarded as early Kimmeridgian to Middle Tithonian. This formation was described as a part of Jurassic outcrops as “Amran Series”. It was described as Madbi formation by with thickness 240m. The type section measured at Jabal Madbi, Shabwah Province, was found to be conformably underlain by Shuqra formation and overlain by either the Tawilah Group in some places or Nayfa formation in the others. This formation is divided into two members. The lower part of this formation is commonly argillaceous lime and basal sand, and forms a good reservoir in some oil fields of the Masila basin. The upper part of Madbi formation is composed of laminated organic rich shale. The lithofaces of this unit reflects open marine environments. The Upper Jurassic organic rich shales of the Madbi formation are considered to be the most prolific oil prone source rock in the basin.

Nayfa Formation: (Amran Group).

The age of the Nayfa formation is between late Tithonian to the Berriasian (Lowermost Cretaceous).Nayfa formation consists predominately of Limestone slightly dolomitic, slightly argillaceous interbedded with minor Dolomite and Shale. In subsurface exploration drilling boreholes, the Nayfa formation was encountered in all the main Yemeni rifted basins. The deposition of the Nayfa formation took place during a new phase of transgression probably associated with the erosion of the marginal barriers that were present during Madbi times that resulted in partial re-introduction of open-marine sedimentation into Sab'atayn and Say'un-Masila basins. The Nayfa formation can be considered as a potential source interval for post rift reservoir.

Saar Formation:

This deposit conformably overlies the Nayfa formation and is composed mainly of limestone, dolomitic limestone with some mudstone, and sandstone. Oil companies classified this formation into lower Saar carbonate and upper Saar clastic. Early Cretaceous syn rift carbonates and clastics of the Saar formation were deposited within the rift in eastern Yemen particularly in Qamar basin whilst thin carbonates were deposited outside the basin. Saar formation is shallow marine deposits environment due to marine transgression.

Qishn Formation: (Tawilah Group).

This is the lowest formation for the Mahra group. Its type section lies in the Mahra at Ras Sharwayn, near Qishn. A reference section for this formation in the western regions was designated at Jabal Rays near Al Mukalla. At its type section, the Qishn formation consists of 411m of fossiliferous limestone with marl interbeds. In the western regions, the reference section of the present formation attains a thickness of about 32m. The sequence includes a basal conglomeratic sandstone this is followed by marl and fossiliferous, sandy, shaly, massive to well bedded limestone. Its lower contact with the Precambrian basement or with the Upper Jurassic rocks is unconformable, whereas its upper contact with the Harshiyat formation is conformable.

Harshiyat Formation: (Tawilah Group).

Harshiyat formation is represented in both the eastern and western parts of the southern provinces of Yemen. A reference section for the Harshiyat formation in the eastern parts was designated in Mahra and Masila, Tihayr area. In its type area the present rock unit consists of 293m of fine to coarse, ferruginous, calcareous, friable to hard, well bedded to massive, current-bedded sandstones with siltstone, shale, marl, dolomitic limestone, and recrystallized, fossiliferous limestone interbeds. This formation extends conformably between the underlying Qishn formation, and the overlying Mukalla formation.

Fartaq Formation: (Tawilah Group).

The occurrence of the Fartaq formation is restricted to the eastern regions of the southern provinces. It is a limestone-marl lateral equivalent of the upper horizons of the Harshiyat clastics of the western regions. Its stratotype lies at Ras Fartaq, Mahra (lat. 15° 59' N, long. 52° 09' E), where it consists of 510m of fossiliferous limestone and marl with a basal shale bed. This formation is conformably underlain by the Qishn for mation, and overlain by the Mukalla formation. The Fartaq formation has yielded a rich assemblage of fossils which dates it as Albian to Cenomanian, to probable Turonian. The formation is divisible into three distinct units which were treated as members. These are in ascending order the DhaSohis, Tihayr, and Maqrat members.

Mukalla Formation: (Tawilah Group).

It is the only formation which persists in the two parts without significant changes in the lithic characteristics. The stratotype lies in the western parts, in Mukalla, at Jabal Al-Rays (lat. 14° 35' N, long. 49° 08 E). The stratotype consists of 165m of colored, fine- to coarse-pebbly, current-bedded, friable to hard sandstones with marl and siltstone interbeds. The current-bedded sandstones represent fluvio-deltaic sediments which are barren of marine fossils. The Mukalla formation thickens westwards. It conformably overlies the Harshiyat formation and unconformity underlies the Umm err Radhuma formation. It conformably overlies the Harshiyat Formation and unconformity underlies the Umm err Radhuma formation.

Sharwayn Formation: (Tawilah Group).

The formation has yielded numerous fossils which date it as Maastrichtian. The Sharwayn formation is the top formation of the Mahra group in the eastern parts of the southern provinces. The formation grades westwards from limestone, through marl and limestone, to marl, sequence. It is conformably underlain by the Mukalla formation, and overlain by the Umm ERR Radhuma formation with probable disconformity.

1.2.1.3 Cenozoic era.

2.1.3.1 Umm Err Radhuma Formation: (Hadramawt Group). The lowermost Umm Err Radhuma formation of Paleocene - Lower Eocene age comprises shallow marine limestones, shales, marls and evaporates with thicknesses that vary from 200m to 700m. The basal Umm Err Radhuma formation contains reworked Maastrichtian fossils indicating a break in sedimentation between the Cretaceous and Tertiary in the east.

Jeza Formation: (Hadramawt Group).

The Jeza formation overlies the Umm Err Radhuma formation conformably with either a gradational or a sharp contact, e.g. east Yemen. It consists of calcareous paper shales and well-bedded fine-grained limestones. To the east the sequence gives way to wake stones and calcareous mudstones. Thicknesses increase to the south from approximately 50m to the northeast to less than 150m north of the Wadi Hadramout.

Rus Formation: (Hadramawt Group).

The Rus formation has gradational and conformable contacts with the underlying Jeza formation, and comprises bedded gypsum and anhydrite with bands of chert, marl, gypsiferous chalk, dolomitic limestone and siliceous diatoms. Thicknesses are around 50m reaching 200m north of Wadi Saqhawat and less than 400m in the west Mukalla area.

Habshiyah Formation: (Hadramawt Group).

The Habshiyah formation, which is about 175m in thickness and overlies the Rus formation, consists of paper shales and chalky limestone.

Shihr Group:

The Shihr group is considered early to middle Oligocene in age. The Shihr group is a transgressive series laid down in coastal embayments and tectonic depressions after emergence of the land surface at the end of the Eocene Epoch. The group consists of limestone, marl, shale, and gypsum, and rests on a variety of older formations.

The group is not represented in the west and west north of Yemen due to high topography in this part or maybe deposited as thin beds and then eroded. The thickness of this group is variable but not less than 60m and not more than 450m. The depositional environment of Shihr group includes estuarine continental and marine [M. Albaroot].

The Habshiyah formation, which is about 175m in thickness and overlies the Rus formation, consists of paper shales and chalky limestone.

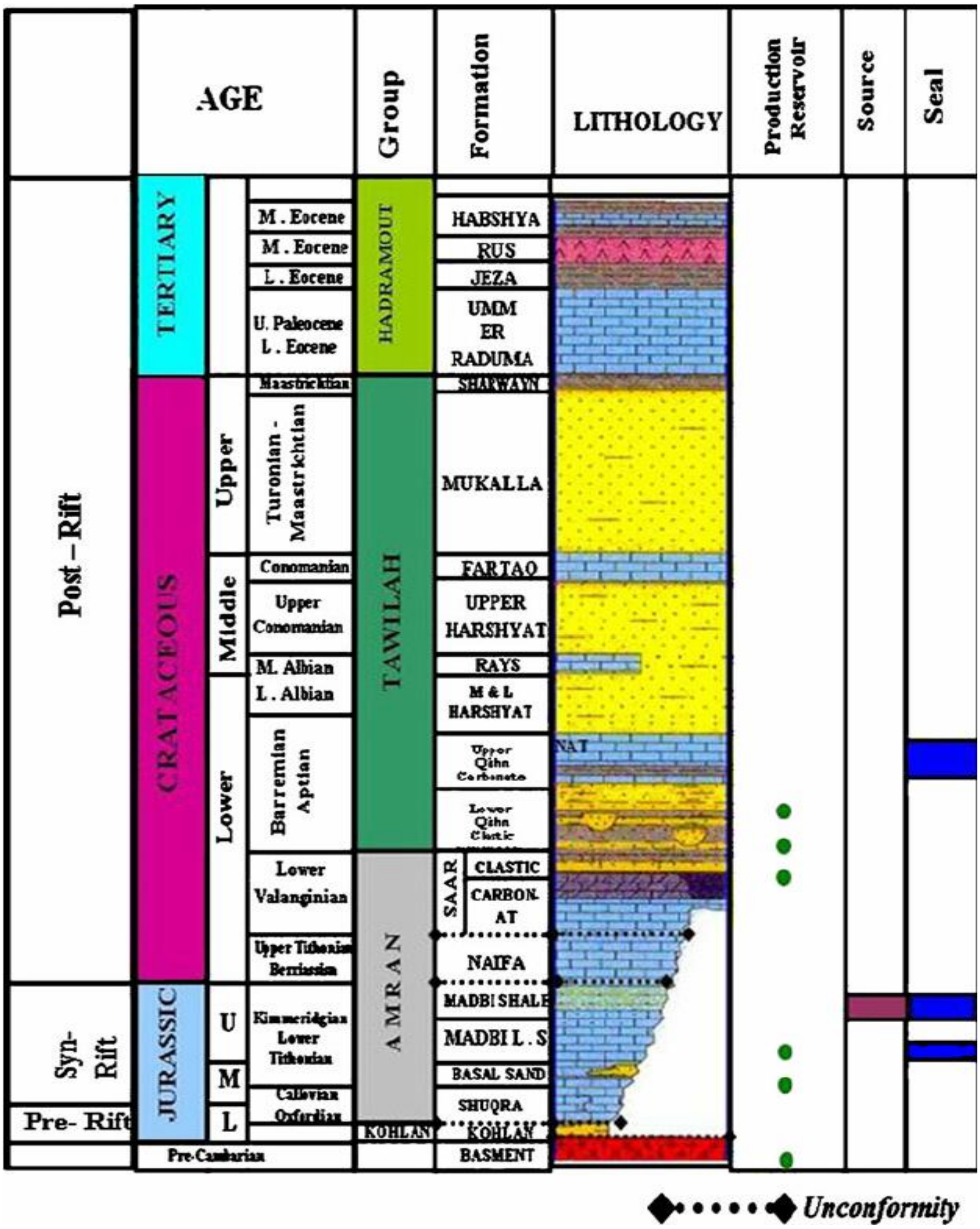


Figure1.2 Stratigraphic column of Yemen

1.3.Masila basin:

Masila Basin is one of the main petroleum basins in Yemen, which is located in the east part of Yemen. Masila Basin is considered as an oil-rich province in Yemen and contains several, well known oilfields.

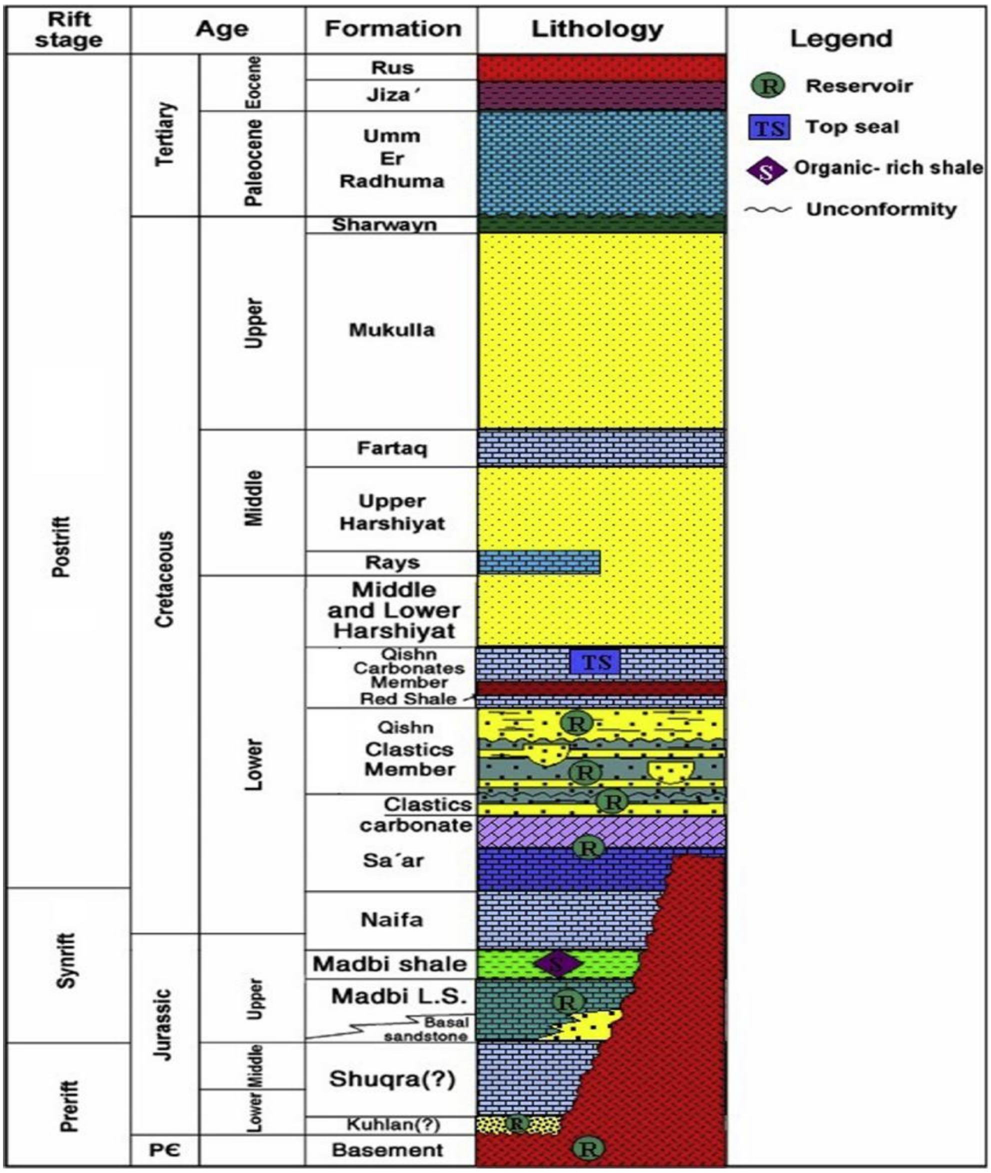


Figure1.3 stratigraphic column in Masila Basin

However, several studies have been performed on the potential source rocks in the Masila Basin, the main source rock in the Masila Basin is Late Jurassic Madbi Formation, which is mainly composited of black calcareous shales with high TOC more than 8%. The Madbi black calcareous shales contain mainly Type I/II kerogens with a minor contribution of kerogen Type II/III.

The Madbi source rock was deposited in a marine environment under suboxic conditions. Masila Basin is one of the Mesozoic sedimentary basins of Yemen, and located in the eastern of Yemen. The Masila Basin is a rift-basin and was initially formed as a result of the Mesozoic breakup of Gondwanaland and the evolution of the Indian Ocean during the Late Jurassic to Early Cretaceous. The Masila Basin also developed during the Oligocene– Middle Miocene time as a result of the opening of the Red Sea and the Gulf of Aden during the Tertiary rifting tectonic event. However, these rifting tectonic events formed several normal faults. The main structures in the Masila Basin are characterized by horst, tilted fault blocks, which are considered as a main structural trap for the hydrocarbon accumulations in Masila oilfields.

1.4.Overview of Block – 53

Block (53) Exist on the North of Saywon Masila Basin between three production block which are block (32) Tasour field from East side, block (10) Kharir field from west side and block (14) Sunah field from South East side. There are three field in block 53

- Sharyoof Oilfield

The Sharyoof oilfield is one of the most productive oilfields in the Masila Basin, located in the N/W sector of the Masila Basin, with area of 474 km2. The Sharyoof oilfield is also located between several successful producing oil fields: The Sunah oilfield to the southeast, the Kharir oilfield to the west, and the Tasour oil discovery to the east .

- Hekma Field

Is the smallest field in block-53, It's structure located on prospective Basemen-Madbi trend between Sunah Field on block-14 some 14 Km to southwest it has one producing well Hekma-1, Which was drilled to a TD of 3715 m in the Basement

- Bayoot Field

The Bayoot oilfield is one of the most productive oil fields in the Masila Basin, located in the N/W sector from the Masila Basin. Bayoot oilfield is also boarded with several successful producing oilfields such as Sharyoof, Sunah, Wadi Taribah, Kharir and Tasour oilfields. The production Bayoot field is started in 2006, the Number of wells have been drilled is 14 well, 9 wells are production wells. The reservoir rock in Bayoot field is basement rocks. The field was operated by Dove company but now is under Petromasila company.

1.5.AREA OF THE STUDY (Sharyoof Oilfield)

The Sharyoof oilfield is one of the most productive oilfields in the Masila Basin, located in the N/W sector of the Masila Basin, with area of 474 km2. The Sharyoof oilfield is also located between several successful producing oil fields: The Sunah oilfield to the southeast, the Kharir oilfield to the west, and the Tasour oil discovery to the east which is currently under development. The first well here, Rudood-l, was drilled in 1999 by the DNO Petroleum Company to a depth of about 2179 m. There followed wells Sharyoof-1 (TD 1765 m) and Sharyoof-2 (TD 1630 m) which targeted the Cretaceous units. The structure types in the Sharyoof oilfield are characterized by horst, tilted fault blocks. These structures were formed during late Jurassicearly Cretaceous and developed during Oligocene–Middle Miocene time as a result of opening of the Red Sea and the Gulf of Aden during the Tertiary rifting tectonic event. The Sharyoof oilfield con tains sedimentary rocks ranging from Jurassic to Tertiary in age, including Saar Formation. The early Cretaceous Qishn Formation is an important hydrocarbon (oil) reservoir in the Sharyoof oilfield (DNO Oil Company, 1999 personal communication). Based on operating oil companies' unpublished data (DNO Oil Company, 1999 personal communication). The productivity varies significantly within the Pre-Cambrian/Archean grantic basement, lower Cretaceous Saar Formation carbonates, and middle Cretaceous Qishn Formation clastic deposits.

1.5.1 Sharyoof reservoir characteristics.

Upper Qishn Formation Clastics:

The primary appraisal objective for this well is the Lower Cretaceous Upper Qishn Formation Clastics that are regionally widespread and have been encountered in all nearby wells. In block 53 area the Upper Qishn Formation Clastics have been subdivided into 3 units: the S1 (top), S2 (middle) and S3 (base). The S1 is divided into three sub units S1C, S1B and S1A (Putnnam et al 1997). The upper S1A unit comprises good quality reservoir sand (Sharyoof-1 average porosity 18.4%, NTG 85%), and are between 8 to 15 meters thick in Block 53. The underlying S1B comprises of non-reservoir, possibly sealing carbonates and mudstones. The basal S1C comprises of poor quality reservoir sands and shales. The S1 sands provide the main reservoir in the region, including Tasour, Kharir, Sunah and Camaal fields. It also tested oil in the Sharyoof-1 discovery well, producing at a rate of 4900 BOPD during an ESP cased hole production test. The best quality S1A sands are understood to have been deposited in a marine near shore environment (eg. sub-tidal shoals) sand passes eastwards into poor quality muddy offshore deposits and westwards into variable quality estuarine and fluvial deposits. Evidence from the presence of poorer quality S1A sands in Rudood-1 (14% average porosity) suggests there was a lateral facies shift to lagoonal and/or estuarine conditions. The S2 and S3 sands form a estuarine and fluvial sand package, with diffuse boundary between the two. The combined thickness varies between 40 and 80 meters in Block 53 and is expected to be 80 meters in the Sharyoof area. Net to gross ranges between 60 to 80% and porosity between 18 and 20% in the Sharyoof area.

Saar Formation:

Dolomites and Clastics Saar Formation dolomites are several hundred meters thick in Tasour-1, thinning onto adjacent fault highs and also thinning to the west (56 meters in Rudood-1, 30 meters in Kharir-3). NTG is likely to be near 100% in the Tasour area, but porosity is expected to be around 10%. The Saar Formation was not included as a possible reservoir in Sharyoof-2. The well program intended 50 m to be drilled to leave sufficient rathole for logging the primary Qishn.

Cap Rock:

It is a unit with low permeability that impedes the escape of hydrocarbons from the reservoir rock

Common seals include:

Evaporates.

Chalks.

Shale.

Seal Potential:

The seal for the Upper Qishn Formation Clastics is the overlying Qishn Formation Carbonate. The Sharyoof-1, Tasour-1, Rudood-1 and Hekma West-1 wells all penetrated in excess of 110 meters of micritic limestone with shaley interbeds, including the Red Shale. The throws on the faults associated with the Sharyoof structure do not exceed the likely Qishn Formation Carbonate thickness, and thus trap integrity is likely to be maintained. In the Tasour-1 well the S1 sand was underlain by limestone which could act as a base seal to the S1 as well as top seal to S2 reservoir. Saar Formation Dolomites and Clastics are likely to be overlain by Saar Formation limestone, which in Tasour-1 provided a top seal [DBDP].

1.6. Problem Statement

The major problems of produced water are the high cost and the environmental risk; which are un-ignorable and in some cases may be the major concerns. The water treating cost for different purposes may considered low, but when compared with huge volumes of the produced water the overall cost will totally risk the economic feasibility of the field. In the other hand, the chemical compositions of the produced water contamination have made many troubles to the surrounding area (e.g. affecting the fresh water sources, damaging the plants and wild life). Although many efforts were made for treating water to meet the standards and the minimum environmental safety for handling, the current work specially diagnoses water production and analyze the control techniques in Sharyoof oilfield.

1.7. The Objectives of the Project:

1. To study Sharyoof field in terms production.
2. To understand reservoir drive mechanism in the field
3. To determine the source of water production and conducting initial diagnosis for water production mechanisms in Sharyoof field for different producing wells.
4. Analyse the performance of a reservoir is by use of quicker and cheaper way
5. Select suitable methods for solving the problem of excessive water production.

Chapter 2

2.1 Introduction :

All oil wells producing water at their life, it comes from the aquifers as a natural drive or even a water flood. However, the water becomes a problem (Excess) when it bypasses the oil and lead to unrecovered accumulations. Generally, the produced water can be categorized into sweep, Good and bad water

2.2 Types of Water Production:

A. Sweep Water

Sweep water comes from either an injection well or an active aquifer that is contributing to the sweeping of oil from the reservoir. The management of this water is a vital part of reservoir management and can be a determining factor in well productivity and the ultimate reserves. When the water cut is great and the oil production revenues are not handling the water treatment cost, the water is called “Bad Water”.

B. Good Water:

it’s the water that cannot be shut off without losing the oil reserves, its happened when the oil and water flow through the porous media as part of the oil’s fractional flow characteristics, as long as the water/oil ratio is below the economical limit the could be considered as a good water.

C. Bad Water:

It is referred specially to the water flow separately into the wellbore and producing no oil or below the well water/oil ratio economic limit lead to increase of the handling cost. It comes usually from a different types of problems classified due to their nature (Reservoir, Mechanical or Complex). Figure 2-1 distinguish between the two types of water.

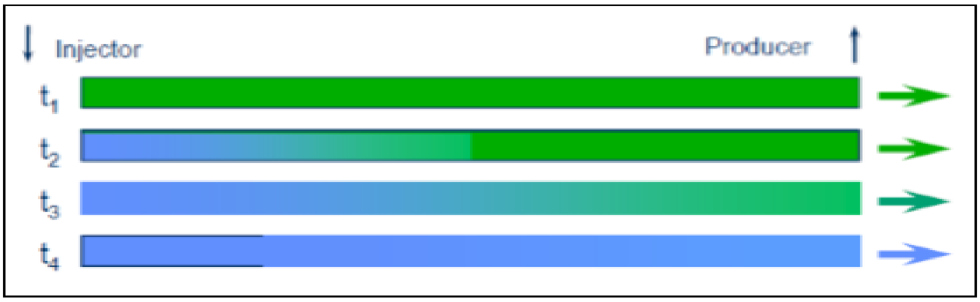


Figure 2.1 Bad Water vs. Good Water (Bailey et al, 2000)

2.3 Sources of Unwanted (Excessive) Water Production:

Excess Water Production Problems:

2.3.1 Casing, Tubing, Packer Leaks:

Leaks through casing, tubing, and packer allow water from nonproductive zone to enter the production string . basic production logs such as density, temperature and spanner may be sufficient to diagnose this problems but in more complex well use WFL water flow logs or multiphase fluid logging such as TPHL three phase fluid holdup log can be valuable. Solution typically include squeezing shutoff fluids and mechanical shutoff using plugs, cement and packers. This problem type is a prime candidate for low cost.

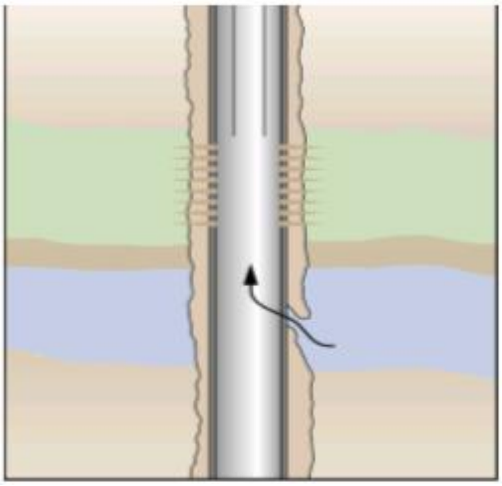


Figure 2.2 Casing, tubing, packer leaks.

2.3.2 Channel Flow Behind Casing:

Failed primary cementing can connect water bearing zones to the pay zone. These channels allow water to flow behind casing in the annulus. A secondary cause is the creation of a „void‟ behind the casing as sand is produced. Temperature logs or oxygen-activation-based WFL logs can detect this water flow . The main solution is the use of shutoff fluids, which may be either high-strength squeeze cement, resin based fluids placed in the annulus, or lower strength gel-based fluids placed in the formation to stop flow into the annulus.

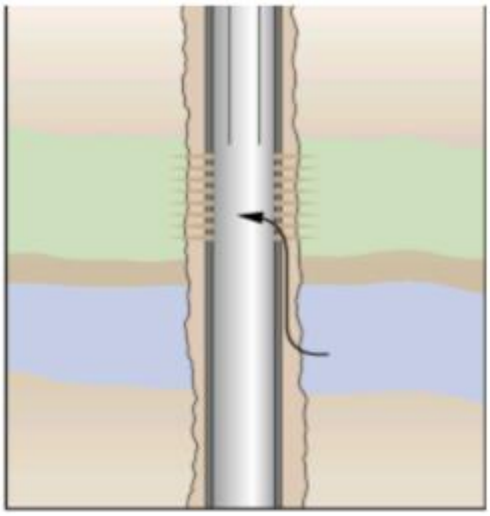
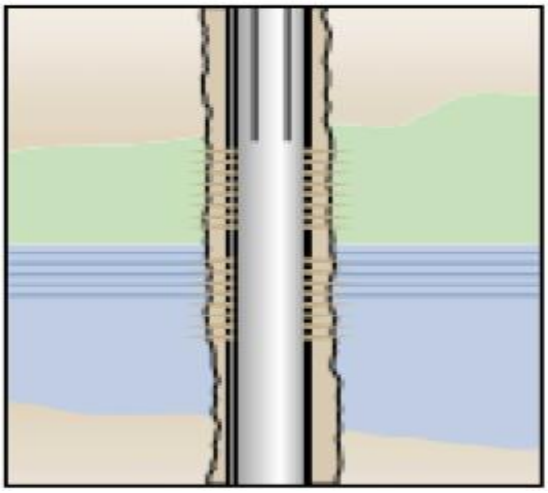


Figure 2.3: Channel flow behind casing

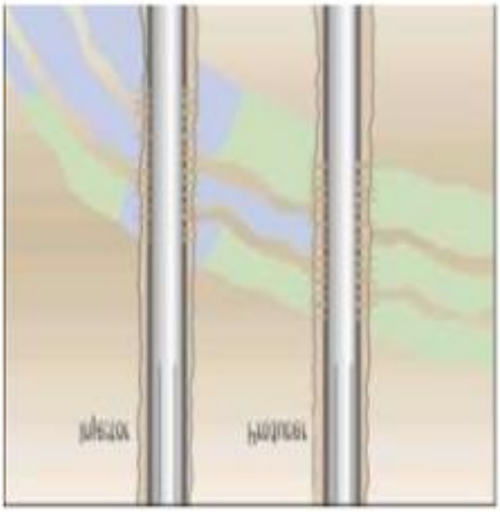
2.3.3Moving Oil-Water Contact:



A uniform oil- water contact moving up into a perforated zone in a well during normal water-driven production can lead to unwanted water production .This happens wherever there is very low vertical permeability, in fact , this problem type could be considered a sub site of coning, but the coning tendency is so low that near wellbore shut of is effective. Diagnoses can not be based solely on known entry of water at the bottom. In a vertical well this problem can be solved easily by abandoning the well from the bottom using mechanical system such as a cement plug or bridge plug. In horizontal wells any wellbore or near wellbore solutions must extend for enough up-hole or down-hole from the water producing interval to minimize horizontal flow of water past the treatment and delay subsequent water break through.

Figure 2.4 Moving oil-water contact

2.3.4 Watered Out Layer Without Cross Flow:



A common problem with multilayered production accrue a high permeability zone with a flow barrier (such as a shell bed) above and below a watered out. In this case, the water source maybe from an active aquifer or a water flood injection well. This problem is easily solved by the application of rigid, shutoff fluids or mechanical shutoff in either the injector or producer. The absence of crossflow is dependent on the continuity of permeability barrier. Horizontal wells that are completed in just one lay not subject to this type of problem.

Figure 2.5 Fractures or faults between injector and producer

2.3.5 Fractures Or Faults Between Injector And Producer:

Producer: In naturally fractured formations under water floods, injection water can be rapidly break through into producing wells. This is specially common when the fracture system is extensive or fissured and can be conformed with use of enter well tracers and pressure transient testing. Tracer logs also can be used to quantify the fracture volume, which is used for the treatment design. Water shutoff is usually the best solution for this problem. Wells with severe fractures or faults often exhibits extreme loss of drilling fluids. If a conductive faults and associated fractured are expected during drilling, pumping flowing jell into the well may help solve both the drilling problem and the subsequent water production and poor swipe problems- particularly in formations with low matrix permeability In horizontal wells, the same problem can exist on the well intersect one or more faults that are conductive or have associated conductive fracture.

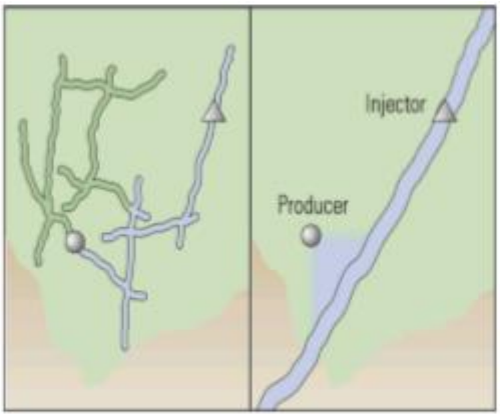
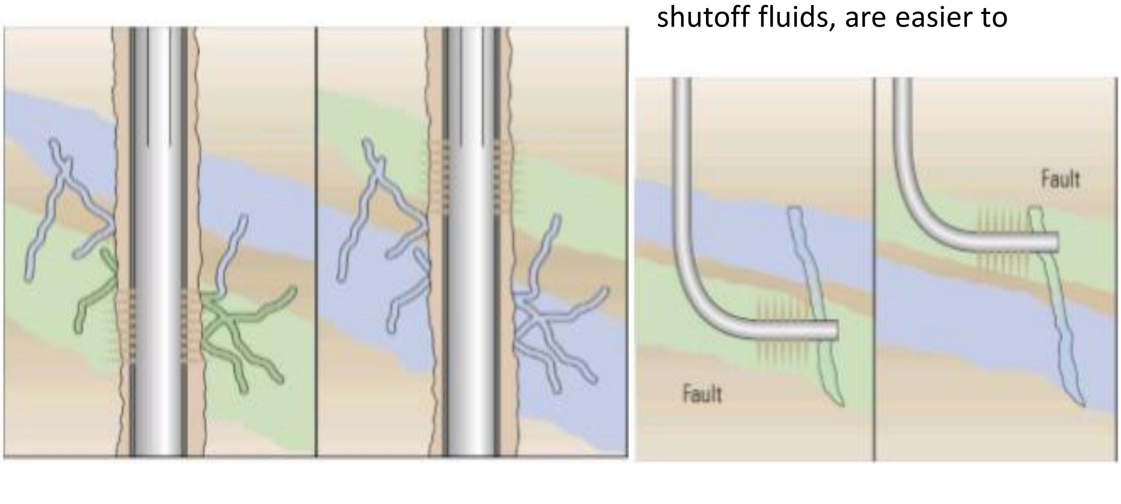


Figure 2.6 Fractures or faults between injector and producer

2.3.6 Fracture Of Faults From A Water Layer:

Water can be produced from fractures that intersect a deeper water zone. This fractures maybe treated with a flowing jell this is particularly successful where the fracture do not contribute to oil production. Treatment volume must be large enough to shutoff the fracture far away from the well,   However, the design engineer is faced with three difficulties.

- First, the treatment volume is difficult to determine because the fracture volume is unknown.
- Second, the treatment may shutoff oil producing fracture ; here, an over-flush treatment maintenance productivity near the wellbore.
- Third, if the following jell is used, it must be carefully tailored to resist flowback after the treatment. Similarly, a degradation in production is caused when hydraulic fracture penetrate water layer. However, in such cases the problem and environment are usually better understood an solution, such as shutoff fluids, are easier to



2.3.7 Coning:

Coning occurs in vertical wells when there is an oil water contact near perforations in a formation with a relatively a high vertical permeability. In horizontal wells, this problem maybe referred to as dunning. In such wells, it maybe possible to at least retard dunning with near wellbore shutoff that extend sufficiently-up and down-hole as in this case of raising water oil contact.

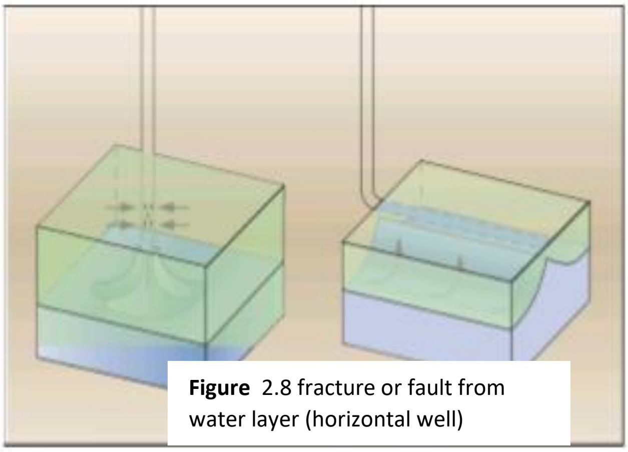


Figure 2.7 fracture or fault from water layer (vertic

Figure 2.8 fracture or fault from water layer (horizontal well)

Figure 2.9 coning

2.3.8 Poor Areal Swipe:

Edge water from an aquifer or injection during flooding through a pay zone often leads to poor areal sweep. Areal permeability anisotropy typically causes this problem, which is particularly severe in sand channel deposits. The solution is to divert injected water away from the pore space, which has already been swept by water. This requires a large treatment volume or continuous viscous flood, both of which are generally uneconomic. Infill drilling is often successful in improving recovery in this situation, although lateral drain-holes may be used to access unswept oil more economically.

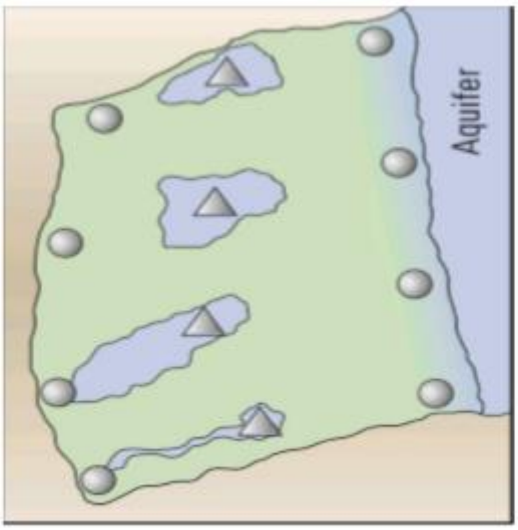


Figure 2.10Poor areal swipe.

Horizontal wells may extend through different permeability and pressure zones within the same layer, causing poor areal sweep. Alternatively, water may break through to one part of the well simply because of horizontal proximity to the water source. In either case, it may be possible to control water by near-wellbore shutoff sufficiently up- and down-hole from the water.

2.7.9 Gravity-Segregated Layer:

In a thick reservoir layer with good vertical permeability, gravity segregation sometimes called water under run can result in unwanted water entry into a producing well. The water, either from an aquifer or waterflood, slumps downward in the permeable formation and sweeps only the lower part of the reservoir. An unfavorable oil-water mobility ratio can make the problem worse. The problem is further exacerbated in formations with sedimentary textures that become finer upward, since viscous effects along with gravity segregation encourage flow at the bottom of the formation. Any treatment in the injector aimed at shutting off the lower perforations has only a marginal effect in sweeping more oil before gravity segregation again dominate. At the producers there is local coning and, just as for the coning case described earlier, jell treatment are unlikely to provide lasting result. Foamed viscous flood fluid may also the vertical sweep. In horizontal well, gravity segregation can occur when the wellbore is placed near the bottom of the bay-zone when the local critical coning rate is exceeds.

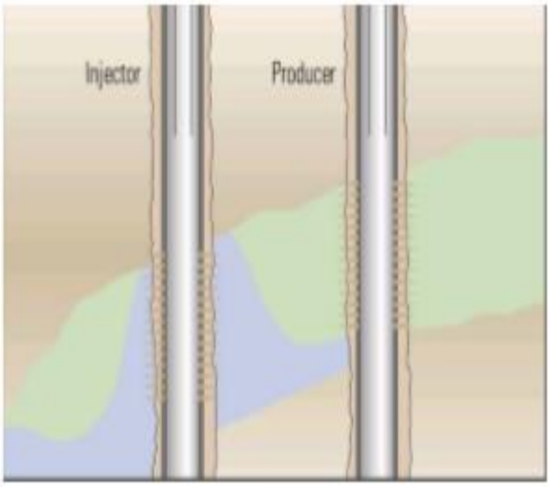


Figure 2.11 Gravity-segregated layer

2.3.10 Watered-Out Layer With Cross-Flow:

Water cross-flow can occur in high permeability layers that are not isolated by impermeable barrier. Water production through highly permeable layer with cross-flow is similar to the problem of watered-out layer without cross-flow but differs in that there is no barrier to stop cross-flow in the reservoir. In this case, attempts to modify either the production or injection profile near the wellbore are doomed to be short-lived because of the cross-flow away from the wellbore. It is vital to determine if there is a cross-flow in the reservoir since this alone distinguished between the two problems when. The occurs without cross-flow, it can be easily treated. With a cross-flow, successful treatment is less likely.

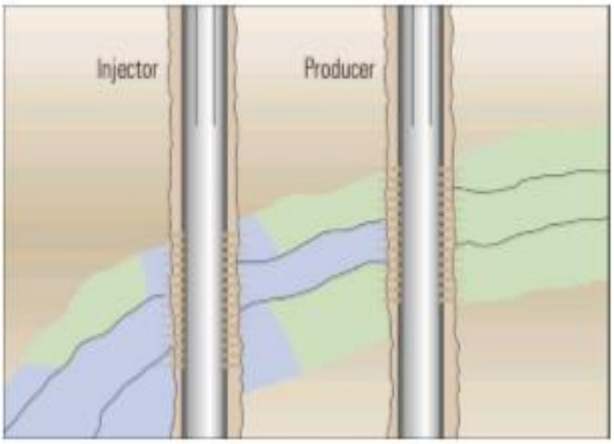


Figure2.12 Watered-Out Layer With Cross-Flow.

2.4 Identifying the Problem:

Reducing excessive water production usually starts with gathering all available reservoir and production data. Then logging tools are used to locate the water entry points. Finally, based on the results, a proper shutoff method is used [Burov,A.;Kharrat,W and Hussein,N.2012]. The most important part in any water shutoff operation is the accurate diagnosis of the problem. It is essential to know the water entry point, the heterogeneity of the reservoir rocks, dominant production mechanisms, and the schematics of the wellbore [Yortsos, Y.C.; Choi, Y.; Yang, Z.; Shah, P.C.1999]. In fact, all available information about the well is considered valuable, like drilling operations reports, logs, and product0ion history. The reason behind that is that every well would have its own workflow based on it is properties, history, and reservoir heterogeneity. Accurate investigation leads to success in the water shutoff operation, increasing oil production, and saving water handling costs. Fayzullin et al.Production logging tools in production wells usually are used to identify the water production zones, which is an important step in planning for an optimized water shutoff operation. For water injection wells, water flow logs are used to identify the thief zones. However, horizontal wells are challenging in identifying the problem as well as in the intervention part. That is due to the complicity of the wellbore, flow regimes, and their effects on obtaining the required information. Luckily, advanced production logging tools can be used to identify the entry points as well as the rates [Ahmad,N.;Al-Shabibi,H.and. Malik,S.2012]. Fiber optics technologies are used nowadays along with logging tools to ensure high quality real time data that help in accurately identifying the water entry zones [. Olarte, J.D.; Haldar, S.; Said, R.2011]. Al-Zainet. al.[Al-Zain, A.; Duarte, J.; Haldar,S.2009] present a case of successful usage of fiber optics to shut off un wanted water production in an oilfield. In addition to that, water/oil ratio (WOR) plots can be used to identify the excessive water production problems. In fact, it can be a more effective tool than logging in many cases as explained in [Al Hasani, M.A.; Al Khayari, S.R.; Al Maamari, R.2008]. For channeling behind the casings, running cement bond logs or ultrasonic pulse-echo logs plays a vital role in ensuring the integrity of the cement job behind the casing. Those kinds of logs evaluate the bonding properties of the cement job behind the casing and point out bad cement areas. For casing leaks, production, temperature, and noise logs are all means of identifying the sources of leaking [Economides, M.J.; Hill, A.D.; Ehlig-Economides, C.2008].

2.4.1 RESERVOIR PERFORMANCE PLOTS AND ANALYSIS FOR WATER PRODUCTION:

According to Sight et al (1997), several methods can be useful in the identification of the source and nature of excess water production. Some of these methods could include simple injectivity and productivity calculations, inter-well tracer studies, reservoir simulation, pressure transient analysis, and various logs. Kinaki (2005) itemized the following plots for the analysis of both the producers and the injection wells. The following plots were identified for producing wells

- Production history plot
- Log of Water Cut or Oil Cut Versus Cumulative Production
- Fetkovich type curves
- Omoriegie-Ershaghi Plot (X plot)
- Dowell-Schlumberger log(WOR) Diagnostic Plot

While for the injection wells, the plots are

- Injectivity curves - pseudo injectivity
- Hall Plots
- Hearn plot

Some of these plots are discussed in the following section.

2.4.1.1 Production history plot

The production history plot is a plot of oil and water rates against production time (Fig. 2.13). This plot helps in visualizing rate changes during the field life cycle and assessing any "uncorrelated behaviors" (Ilk et al. 2007) such as changes in the rate without corresponding changes in pressure. Wells with water production problem usually show a simultaneous increase in water production with a decrease in oil production (Bailey et al. 2000).

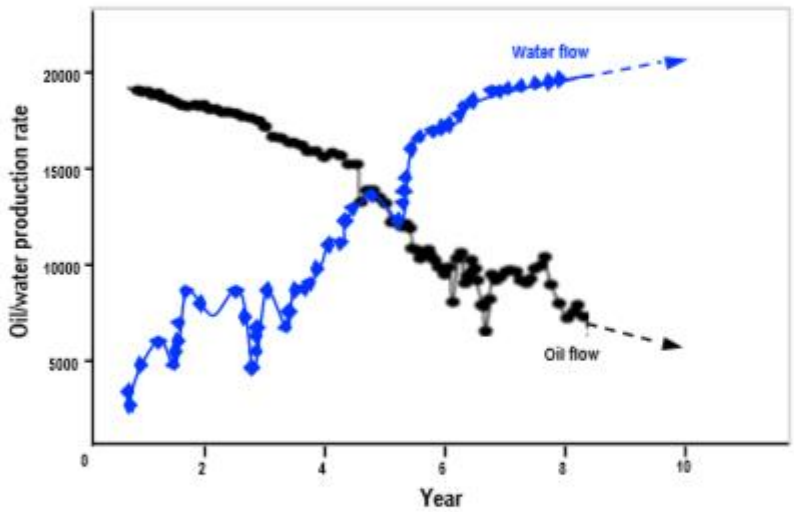


Figure 2.13 An example production history plot

2.4.1.2 LOG OF WATER CUT OR OIL CUT VERSUS CUMULATIVE PRODUCTION

According to Bondar (1997), the logarithm of WOR or water cut (fw) function plotted against cumulative production is commonly used for evaluation and prediction of water flood performance. This presumed semi-log plot of fw and oil recovery allows extrapolation of the straight line to any desired water-cut as a mechanism for determining the corresponding oil recovery. Straight-line extrapolation method assumes that the mobility ratio is equal to unity and the plot of the log of relative permeability ratio of the flowing liquids, (krw/kro), versus water saturation, Sw is a straight line. According to Omoregie and Ershaghi (1978), this approach is only applicable for fw greater than 0.5 and it should not be used during the early stage of a water flood.

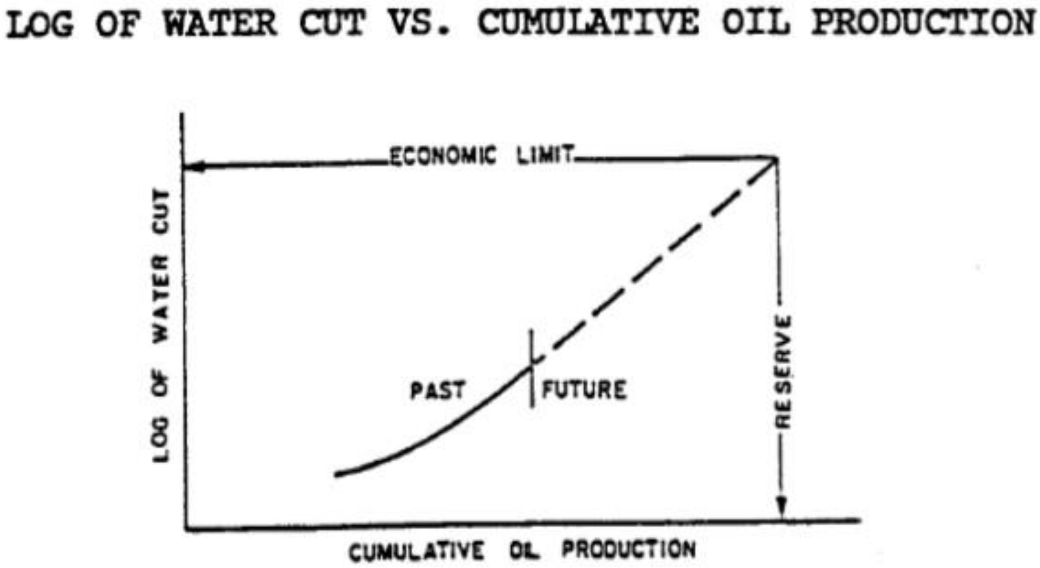


Fig 2.14 Production plot showing log of water cut versus cumulative oil production (Satter and Thakur, 1994)

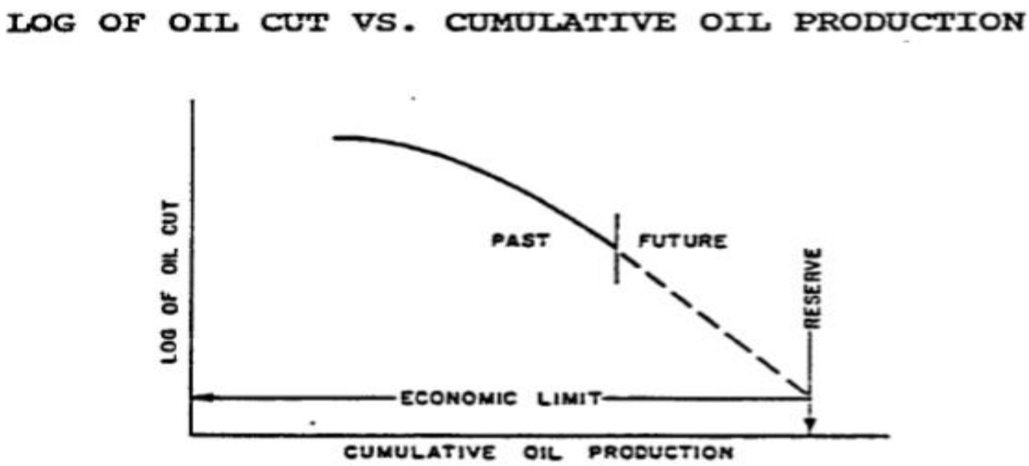


Fig 2.15 Production plot showing log of oil cut versus cumulative oil production (Satter and Thakur, 1994)

2.4.1.3 HALL AND HEARN PLOT FOR INJECTORS

Hall and Hearn method are applicable to water flooded operations where injection wells are surface pressure controlled and where bottom hole injection just below formation parting pressure (FPP) is desired (Jarrel and Stein, 1991). These methods help in monitoring the acceleration of fill-up and average reservoir pressure growth in an actual field. While the Hall plot is the plot of the bottom hole injection pressure versus the cumulative water injected, Hearn plot is the plot of inverse injection index versus cumulative water injection. Monitoring these plots as pressure and rate increases renders qualitative interpretation of whether the rates are being maintained below the formation parting pressure (FPP). The assumptions inherent in these plots are piston-like displacement, steady state, radial single phase and single layer flow with the reservoir pressure, pe being constant. It is also assumed that there is no residual gas saturation in the water and oil zones. The Hall and Hearn plots can be used to determine reservoir properties such as transmissivity (kh) etc as reservoir condition changes. These plots are based on the radial, steady state .

According to Chan (1995), the above plots could be useful to evaluate production efficiency, but they do not reveal any detail on reservoir flow behaviours. Although, some of the plots could show reservoir characteristics, they do not shed any clue on the timing of the layer breakthrough. Therefore the need for the diagnostic plot was proposed by Chan. It reveals detailed reservoir flow behaviours, the timing of the layer breakthrough and the relationship between the rates of change of the WOR with the excessive water production mechanism.

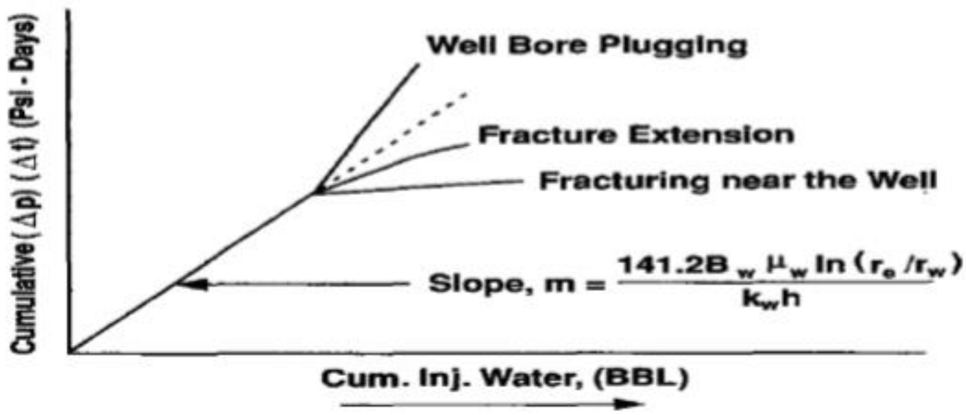


Fig 2.16 The Hall Plot (Jarrel and Stein, 1991)

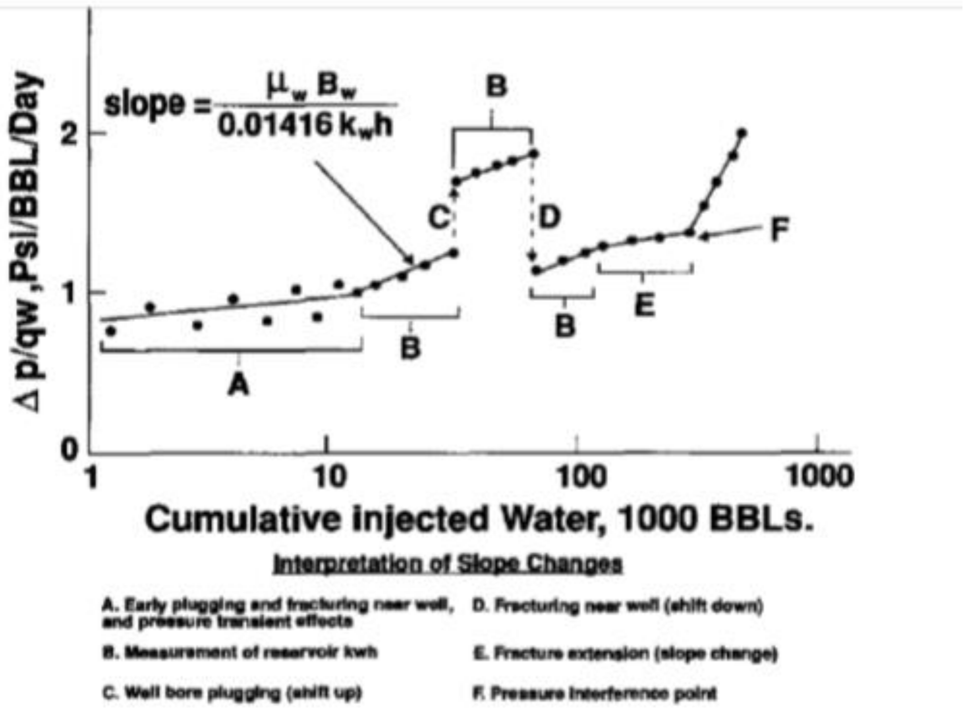


Fig 2.17 The Hearn Plot (Jarrel and Stein, 1991)

2.4.1.4DIAGNOSTIC PLOTs

According to Chan (1995), the log-log plots of WOR (Water-Oil Ratio) versus time or GOR (Gas-Oil Ratio) versus time show different characteristic trends for different mechanisms. The time derivatives of WOR and GOR were found to be capable of differentiating whether the well is experiencing water and gas coning, highpermeability layer breakthrough or near wellbore channelling. Chan identified three most noticeable water production mechanisms namely water coning, near well-bore problems and multi-layer channelling. Log-log plots of the WOR (rather than water cut) versus time were found to be more effective in identifying the production trends and problem mechanisms. !t was discovered that derivatives of the WOR versus time can be used for differentiating whether the excessive water production problem as seen in a well is due to water coning or multilayerchannelling. Figures 2.12 through 2.15 (Chan, 1995) illustrate how the diagnostic plots used to differentiate among the various water production mechanisms. Fig. 2.15 shows a comparison of WOR diagnostic plots for coning and channelling. The WOR behaviour for both coning and channelling is divided into three periods; the first period extends from start of production to water breakthrough, where the WOR is constant for both mechanisms. When water production begins, Chan claims that the behaviour becomes very different for coning and channelling. This event denotes the beginning of the second time period. For coning, the departure time is often short (depending on several variables), and corresponds to the time when the underlying water has been drawn up to the bottom of the perforations. According to Chan, the rate of WOR increase after waterbreakthrough is relatively slow and gradually approaches a constant value. This occurrence is called the transition period. For channelling, the departure time corresponds to water breakthrough for the most water-conductive layer in a multi-layer formation, and usually occurs later than for coning. Chan (1995) reported that the WOR increases relatively quickly for the channelling case, but it could slow down and enter a transition period, which is said to correspond to production depletion of the first layer. Thereafter, the WOR resumes at the same rate as before the transition period. This second departure point corresponds to water breakthrough for the layer with the second highest water conductivity. According to Chan, the transition period between each layer breakthrough may only occur if the permeability contrast between adjacent layers is greater than four. After the transition period(s), Chan describes the WOR increase to be quite rapid for both mechanisms, which indicates the beginning of the third period. The channelling WOR resumes its initial rate of increase, since all layers have been depleted. The rapid WOR increase for the coning case is explained by the well producing mainly bottom water, causing the cone to become a high-conductivity water channel where the water moves laterally towards the well. Chan (1995), therefore, classifies this behaviour as channelling. Log-log plots of WOR and WOR time derivatives (WOR') versus time for the different excessive water production mechanisms are shown in Figures 2.13 through 2.15. Chan (1995) proposed that the WOR derivatives can distinguish between coning and channelling. Channelling WOR' curves should show an almost constant positive slope (Fig. 2.), as opposed to coning WOR' curves, this should show a changing negative slope (Fig. 2.). A negative slope turning positive when “channelling”occurs as shown in Figure 2.15, characterizes a combination of the two mechanisms. Chan classifies this as coning with late channelling behaviour.

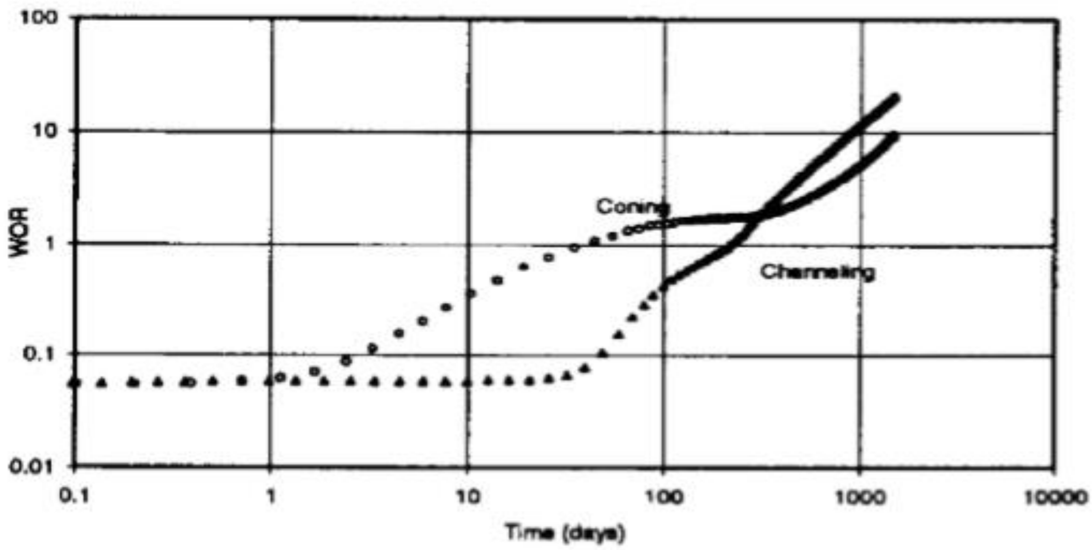


Fig 2.18 Water coning and channelling WOR comparison. Chan (1995)

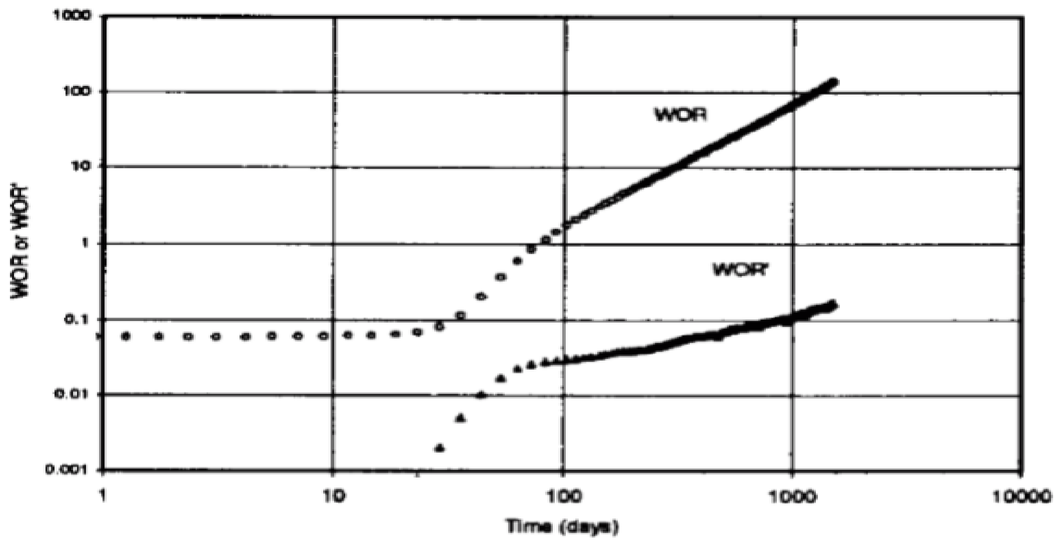


Fig 2.19 Multi-layer channelling WOR and WOR derivatives. Chan (1995)

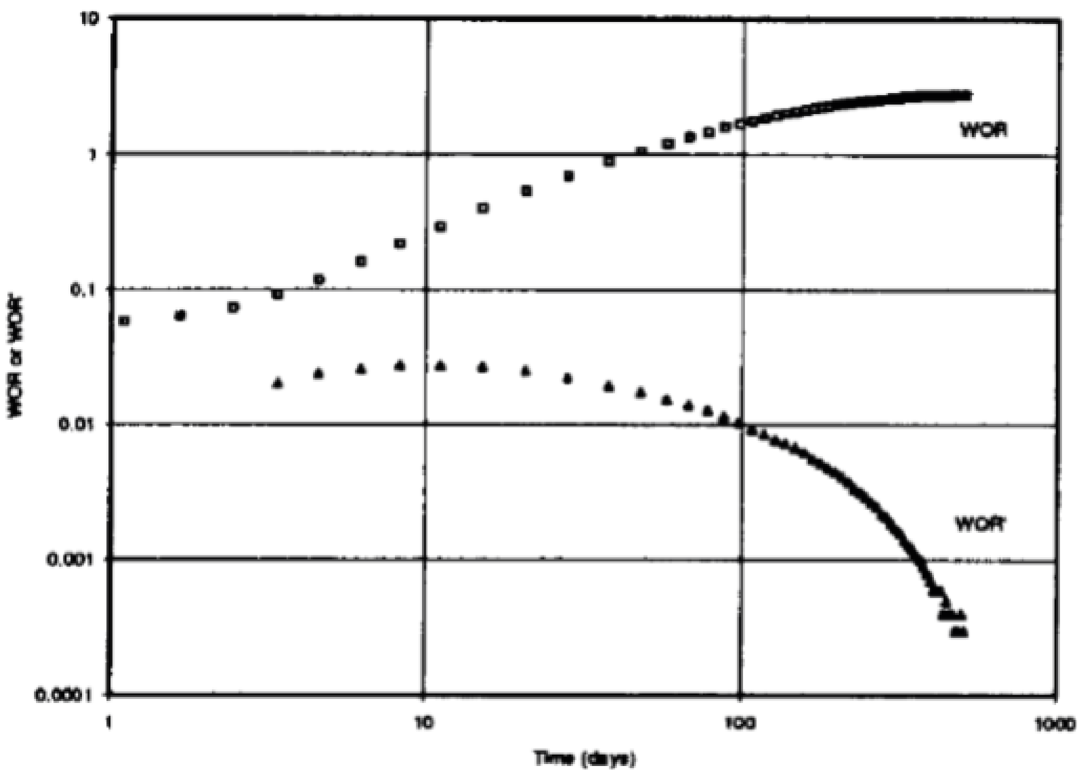


Fig 2.20 Bottom-water coning WOR and WOR derivatives. Chan (1995)

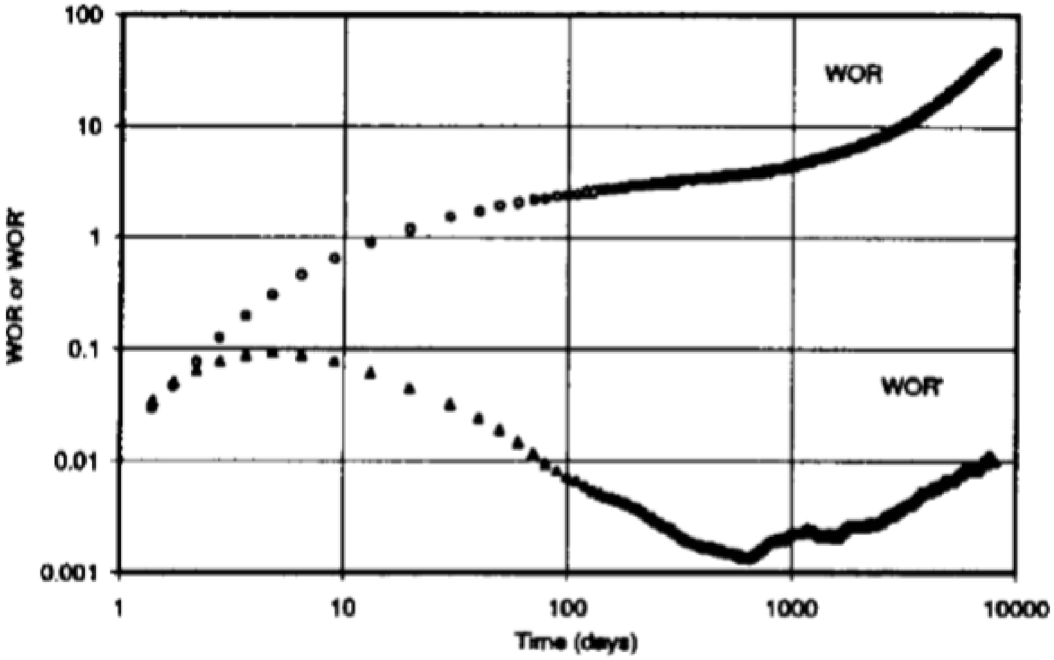


Fig 2.21: Bottom water coning with late time channelling. Chan (1995)

Recently, the use of Chan's WOR diagnostic plots has received significant interest in the oil and gas industry (Seright, 1997).

2.5 Water Shutoff Operations and Techniques :

2.5.1 Chemical Solutions:

Far from the wellbore, in the reservoir or near the wellbore, water shutoff operations can be performed by several chemical treatments. Those chemical solutions lead to better conformance in the reservoir as well as blocking the unwanted water production zones. The idea is to be able to close the paths of least resistance in front of the water by reducing their permeability in order to prevent the water from coming to the wellbore through them. Also, they aid in forcing the water to mobilize and displace the oil in the reservoir. In other words, the aim is to block the open features and high permeability channels to force water to go toward the harder path to sweep oil from the matrix rock that results in higher overall economical returns than producing oil from fractures. In fact, induced formation damage can be used as an effective solution to control the unwanted water production [Zeinijahromi, A.; Bedrikovetski, P.2015]. The results of chemical solutions can be achieved in a couple of months to years, depending on the nature of the reservoir and the properties of the injected chemicals. The main advantage that chemical water shutoff operations have over mechanical operations is that they solve the problem of the unwanted water production instead of hiding it under or behind a plug, packer, or tubing patch. Injected chemicals can reach water features in the reservoir and reduce the permeability, resulting in closing them entirely. They also have the freedom of moving between the layers and features which helps in reaching to far extents and completely closing them. Another use of chemical injection is to increase the viscosity of the injected fluid which leads to a better sweeping efficiency and eventually reduces the production of unwanted water. The success of chemical injection operations depends on the knowledge level of the reservoir and its characterizations , chemical properties , and accurate placement of the injected chemicals [Surguchev, L.M. 1998]. For example, the effectiveness of water shutoff agents depends highly on the properties of the reservoir and has to be compatible with the reservoir temperature and water salinity in order to achieve an effective water shutoff [Sun, Y.; Fang, Y.; Chen, A.2017]. In this section, common chemical solutions are discussed in detail, along with examples of the execution of the operations .

2.5.1.1 Gel

Gel injection is one of the most famous chemical solutions for water shutoff operations. It is used to reduce the water oil ratio. That happens through the ability of the gel to reduce th e permeability and block the open features, fractures, and high permeability water zones. It can be applied in the wellbore, near the wellbore, and far from the production well through injection wells. It is very effective in reducing the permeability of unwanted zones and has proven its ability to improve the sweep efficiency and shutting-off the unwater water zones. The injected gel is mainly made of water, small volumes of polymers and crosslinking chemical agents [Sydansk, D. and Romero-Zeron, L.2011]. Gel treatments can completely seal off layers; therefore, they are considered aggressive and risky conformance control operation

[3]. On the other hand, polymer gel injection is considered relatively cheaper than other improved oil recovery operations. Gel injection operations are divided into three main stages: modeling, designing, and executing. The first step is to model the gel injection operation by using simulation software , which is an important step for designing the program of gel injection operation[18]. In this stage , all the available information about the reservoir and the well are considered valuable, such as: reservoir parameters, water entry points, drilling operations reports, logs, and production history. The second step is to design the properties of the polymer gel fluid. Injecting gel in the reservoir depends on four properties. First one is the viscosity of the gel at the time of injection which helps in directing the gel to the lager and least resistance paths. Second is the nature of the gel phase which is usually chosen to be the aqueous phase since the water is the desired phase to be shutoff. Third is the density of the gel. It very important to be designed carefully and based on the density of the formation water to avoid losing the effectiveness of the gel treatment. Four this the setup time or injection time. Longer injection time leads to more success in allowing the gel to seal off larger features and least resistance paths [3]. Al-Dhafeeri et. al. [20] present a case study of using gel treatments as a chemical solution to seal the excessive water zones.

2.5.1.2 Polymer Flooding

Another common technique for water shutoff operations is the usage of the polymer flooding method to increase the viscosity of the water. This technique is applied to increase the viscosity of the drive fluid (water) which helps in mobilizing and displacing the oil in the reservoir matrix rock. This technique is usually applied in the reservoir far from the production wells through water injection wells to achieve better sweeping efficiency in the reservoir. That eventually leads to preventing excessive water production. The usage of polymer flooding is very common among the oil operators and it can be prepared by dissolving the polymers in the injected water and inject it through injection wells. Polymers used in this technique are usually two types: biopolymers and synthetic polymers. Biopolymers' advantages over the synthetics are that they are not affected by the salinity of the water and they are insensitive to the mechanical degradations. However, they are more expensive than synthetic polymers. Xanthan and scleroglucan are two famous kinds of biopolymers. Synthetic polymers are more common since they are cheaper, more available, and perform well with low-salinity water. Polyacrylamide (PAM) and hydrolyzed polyacrylamide (HPAM) are two types of synthetic polymers. Polymers can also play a role in reducing the permeability if the molecular weight is increased Sydansk, D.and Romero-Zeron, L 2011]. Finally, based on the characteristics of the reservoir and the economics of the operations, the right polymer is chosen in case of chemical injection [. Gharbi, R.; Alajmi, A.; Algharaib, M.2012].

2.5.2 Mechanical Solutions:

Within the wellbore, there are available technologies which can successfully shutoff the unwanted water production. The impact can be seen in hours in contrast to the chemical solutions which was discussed in the previous section. Controlling the water production mechanically is known for it is fast outcomes as well as its cheap costs. It is usually a rigless job, which means a lower cost [. Ahmad,N.;Al-Shabibi,H.and Malik,S.2012]. Mechanical water shutoff operations are preferred by operators since they are relatively cheaper than chemical solutions [Permana, D.; Ferdian, G.; Aji, M.and Siswati, E.2015]. Once more, an accurate diagnosis is essential before attempting to apply those solutions, since it can result in losing the oil production from the well. That can be achieved, as mentioned previously, through running logs to identify the water production zones. In the case of mechanical shutoff operations, there are some factors affecting the success of them. One of them is the setting depth of the plug or the packer can be wrong due to in accurate readings from the coiled-tubing meter. The reservoir conditions also play a great role in affecting the operations, since a cross flow between the layers can happen and leads intervention to failure. The wellbore condition is another vital factor which needs to be considered. Scale presences in the tubing can result in failure of the operations, since it can create an obstacle while running the plug or the packer downhole. Wells with high deviation angles can be challenging to run in hole with coiled-tubing since they can get stuck a lot [Denney, D.et al 2001]. In this section, common mechanical solutions are discussed in details along with examples of the execution of the operation.

2.5.2.1 Plugs and Packers :

One of the most well-known mechanical solutions for water shutoff and isolation operations inside the wellbore is the installation of packers and plugs. They are successful in eliminating the production from unwanted water zones. They are commonly used by oil operators to aid the wells performance and shut off the excessive water production [Offenbacher, M.; Gadiyar, B.; Messler, D.2015]. This hardware is known for being economical and reliable in achieving isolation since it can be installed without pulling the production tubing and without the drilling rig. They can be installed by using coiled tubing which can run them through the wellbore. Also, the results can be achieved relatively fast, in a couple of hours to days, in contrast with chemical injection solutions. Simply , the concept of packer sand plugs is a small diameter element, mainly rubber, which can expand downhole the wellbore into larger diameters, creating a seal and isolating the well from unwanted features or zones [26. Wilson, P.and Hoffman, C.E.2000]. There are different types of packers and plugs with different properties and setting techniques. Some elements expand by interacting with certain types of fluids (oil, water, or hybrid) which are known as 'swellable packers'. They also depend on pre-designed properties like temperature ,pressure, and salinity of the formation fluid. That can be a disadvantage in some cases and leads to failure in setting the element. If those properties are not accounted for accurately, that might lead to a faster inflation of the elements or even slower inflation than expected. In the worst case scenario, the element might not inflate at all. Other packers and plugs inflate by applying pressure on the element in order to expand and seal. These types of plugs usually inflate by pumping darts, steel balls, or fluid to apply pressure on the rubber element and allow it to expand and increase its diameter. Packers and plugs can be used to isolate unwanted water production inside the wellbore in certain cases. An easy example would be an open-hole well completion and the water zone is identified to be from the bottom of the well. A bridge plug can be installed to isolate the bottom section and shut down the additional water production to aid the production performance from upper oil zones (Figure 6). The difficulty increases if the water source happens to be in the middle or at the top part of the production section of the tubing in the reservoir section. In that case, a blank pipe with upper and lower packers ,

with apre-designed length, can be installed to isolate the water production area without compromising the lower and upper oil production zones (Figure 7). In the case of a multi-lateral wells, if one of the laterals is watered-out or producing extreme amounts of unnecessary water, it can be abandoned by setting a plug to isolate it from other laterals. The usage of packers is also used in early stages of the well life, specifically in the completion stages after drilling. That is a common practice for operators who have a reasonably decent knowledge of the expected features and layers of their reservoir. Also logging while drilling tools can be an asset by identifying the open features which might be the future reason for bad water production. After drilling the well and collecting the data, a pre-perforated liners can be installed with packers to produce only the good layers and isolate the risky formations. Once more, an accurate and cautious pre-design of the job is essential for designing the elements to avoid failures.

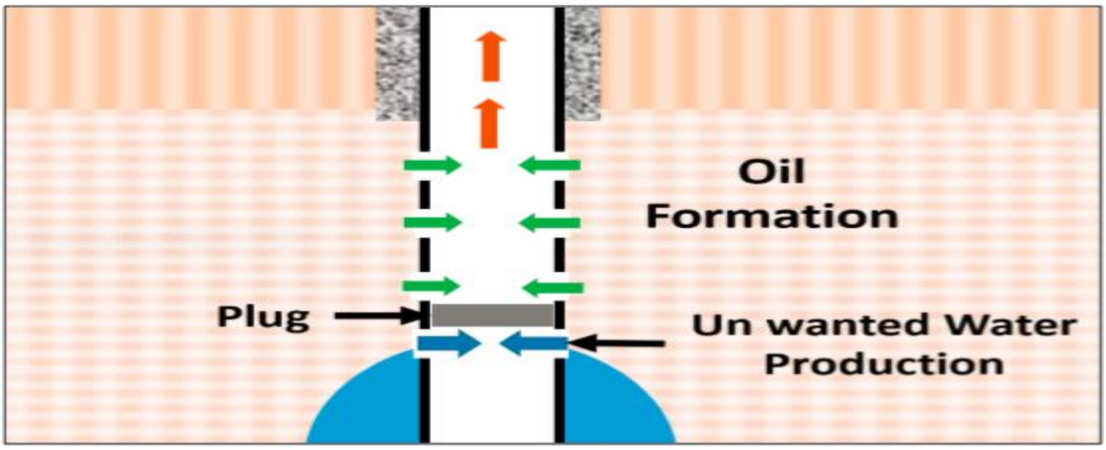


Figure2.22 Using a plug to shut off the production of water from the bottom.

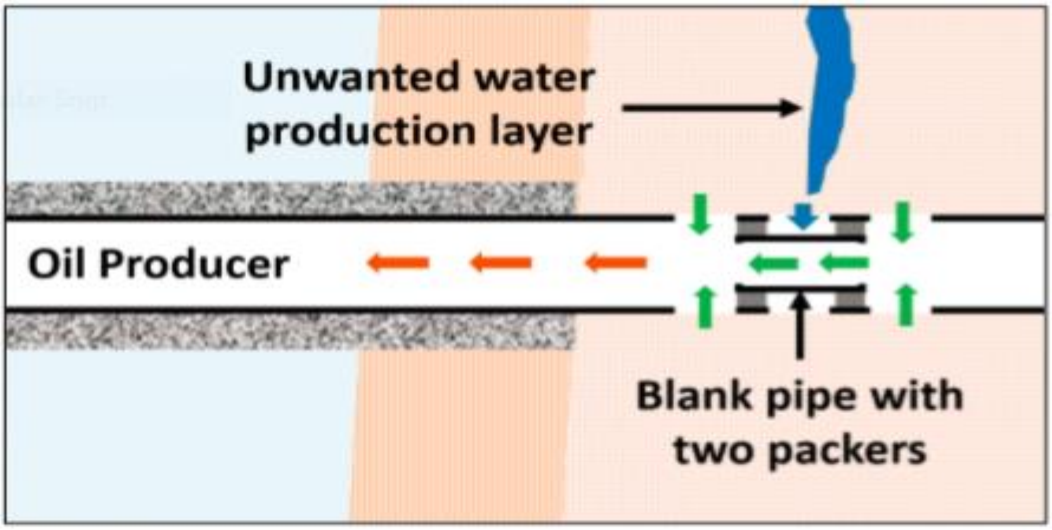


Figure2.23 Two packers above and below a blank pipe to shut off the production of water from the middle and upper intervals without compromising other oil production zones .

Likewise, for water injection wells, those plugs can be used to insure better conformance outcomes and to eliminate the production of bad water from the production wells through thief zones, high permeability layers, or connected open features. For example, if any of the previous features have been identified in the injection profile of water injection well, plugs can be used to isolate injected water from going into them. If there is an open feature at the bottom of a water injection well, a plug can be installed to isolate the bottom section, to avoid wasting the injected water and direct it into oil matrix rocks instead. Similarly, if the feature happens to be at the middle or the top of the injection profile, a blank pipe with upper and lower packers can be installed to isolate the thief zones from stealing the injected water without compromising the conformance and the sweeping installed to isolate the thief zones from stealing the injected water without compromising the conformance and the sweeping efficiency of the field (Figure).

Other than that, inflatable packers are also used in chemical injection for water shutoff operations. As mentioned previously, chemicals can be used in the near wellbore area to control and shut off the unwanted water production. However, this operation considered risky because of the high cost and the risk of injecting the chemicals into the oil production zones [Plante,M.E.and Mackenzie,G.R.J.2000]. Therefore, packers are used to direct the flow of the injected chemicals into the desired layers and prevent fluid from going into the production formation. Packers create a seal by inflating and isolating the upper and bottom intervals to make sure that chemicals do not bypass to the oil zones.

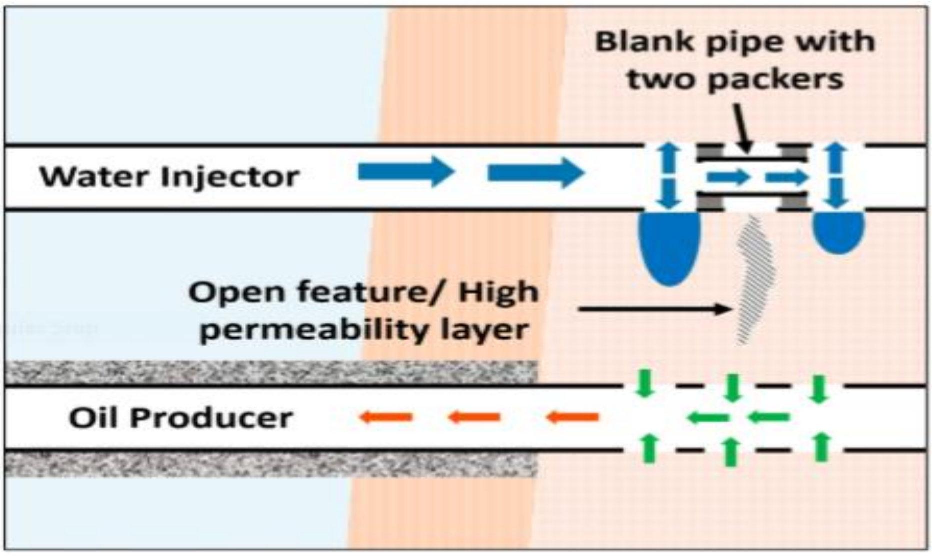


Figure2.24 Two packers above and below a blank pipe to avoid injecting the water in open features or high permeability layers.

2. 5.2.2 Tubing Patches:

This method is mainly used for fixing well integrity issues particularly casing leaks. The casing leaks problems are common in old wells and the wells which are completed in formations with corrosive gases like H2S [Lizak,K.F.;Zeltmann,T.A.;Crook,R.J.1992 and . Meek, J.W.; Harris, K.1993]. If the source of the unwanted water was found to be from a leak in the casing, squeezing cement or resins patches is considered to be a suitable solution. This method can be applied only after identifying the exact location of the leak through the methods discussed earlier. Squeezing jobs can be performed by rigs or sometimes with current technologies can be a rigless job. Usually, inflatables are used to direct the patches toward the leaking point [. Bybee, K. Unique Rigless Casing Leak Repair. J.2001]. For small leaks, fine cement particles are squeezed to fix the well integrity issue as well as creating a seal [Lizak,K.F.;Zeltmann,T.A.;Crook,R.J.1992].

CHAPTER 3

METHODOLOGY

3.1. Introduction:

This chapter deals with the methodology and the major directions of this research.

The production well performance evaluation and diagnostics deals with various plots on well evaluation and diagnostics

The injection well performance evaluation plots and the diagnostic plots.

3.2. Type of Data Required to Implement Project

- Daily oil production
- Daily water production
- Gas producti11on
- Number of production days in month

3.3 FIELD PRODUCTION PERFORMANCE EVALUATION

This entails the plots of the field data to determine how well the field is producing based on the oil and water production rates and time.

The plots considered here are:

- Oil and water production rates with time

3.4 FIELD PRODUCTION DATA DIAGNOSTIC PLOT

The diagnostic plots for the field and well production are described for identifying the nature and the cause of the water production problems; that is, the water production mechanisms in the reservoir.

The plots considered for the diagnosis are

- The Log-Log plot of Water Oil Ratio with time

- The Log- Log Plot of Water Oil Ratio derivative with time

The WOR and the WOR derivative (WOR') plots are used in combination to diagnose the reservoir related water production mechanism prevailing in the reservoir. It takes into cognisance that an upward sloping of the WOR plot with time indicates increased water production. It also considers that the upward sloping of the WOR derivative indicates multilayer channelling while the downward sloping indicates water coning. For the purpose of this work, the centre difference first order derivative approach is used to determine the WOR’.

3.5 Software To Be Used

OIL FIELD MANAGER Program (OFM)

3.6 Anticipated Results:

It takes into cognisance that an upward sloping of the WOR plot with time indicates increased water production. It also considers that the upward sloping of the WOR derivative indicates multilayer channelling while the downward sloping indicates water coning. For the purpose of this work, the centre difference first order derivative approach is used to determine the WOR’. Where WOR’ is given by

WOR Slope	WOR' Slope	Reason for Water Production
Positive	Positive	Channeling
Positive	Negative	Coning
Positive linear slope	Horizontal line	Water/oil contact rising

CHAPTER 4

After field start to produce oil the water production increase was so excessive that probably reasons of fault and high permeability. The well(sh2) is produce from S1A and it's perforations top equal to 1453.2 MDRKB and bottom perforation equal to 1470.2 MDRKB there is too much water and too little oil produced from the well. the increase of liquid from well in 2004 is attributed to the start of injection in (sh1) In S1A layer. as (sh1) continues injection at higher rates during 2004 and 2005, the rates and pressures in (sh2) also trend higher. In well (Sh9) is produce from S1C layer it's perforations top equal to 1479.5 MDRKB and bottom perforation equal to 1484 MDRKB. The well (sh23)

4.0 RESULTS AND DISCUSSION OF RESULTS

The results obtained from The Study are presented and discussed in this section. The order of the discussion is thus;

- The field performance.
- The performance evaluation and diagnostics of the producing wells from the simulation as well as that of the Case study are presented.

4.1 ANALYSIS OF FIELD OIL RATE AND WATER RATE PLOTS

Oil rate and water rate versus time plots of the field data for The Case Study are

analyzed in the following section. Figures 4.1 and 4.4 shows the graph of the field

and well production rates, respectively .As deduced from the s results, oil rate would decline with increase in water production. These can be seen in the field plots (Fig 4.1) and the individual well plots (Fig 4.2). The plot of oil and water rate with time shows the point of equal oil rate and water rate and beyond . It is noted that individual well plots (e.g., Fig. 4.2 to 4.4) show the sequence of events (like well shut-ins) during the production of the wells.

Shryoof Production Rate With Time

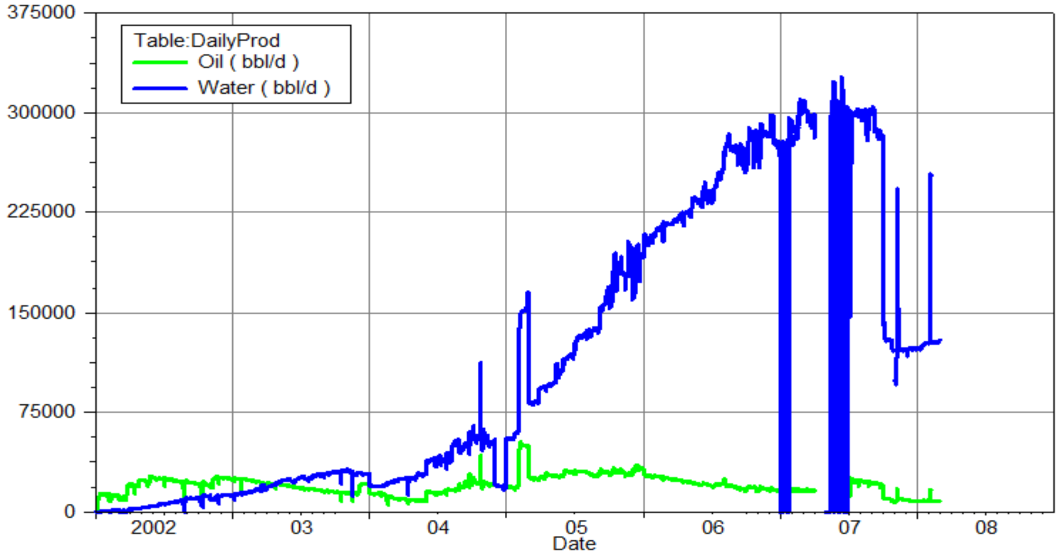


Fig 4.1 : field production rate versus time

In 27-Sep-2006 Workover job was performed to Sh002 to change the ESP pump HR13599, 65 stages with HR13500 ESP pump, 116 stages without Y tool (Y-tool has unable to be run due to large OD of assembly).these is cause icrease of water and oil production rate.

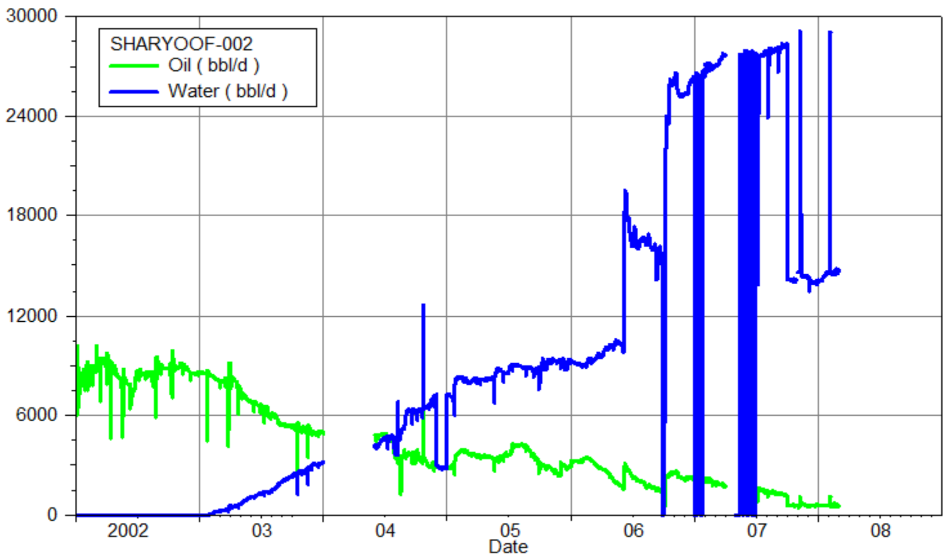


Fig 4.2 : Well production rate versus time (Well 002)

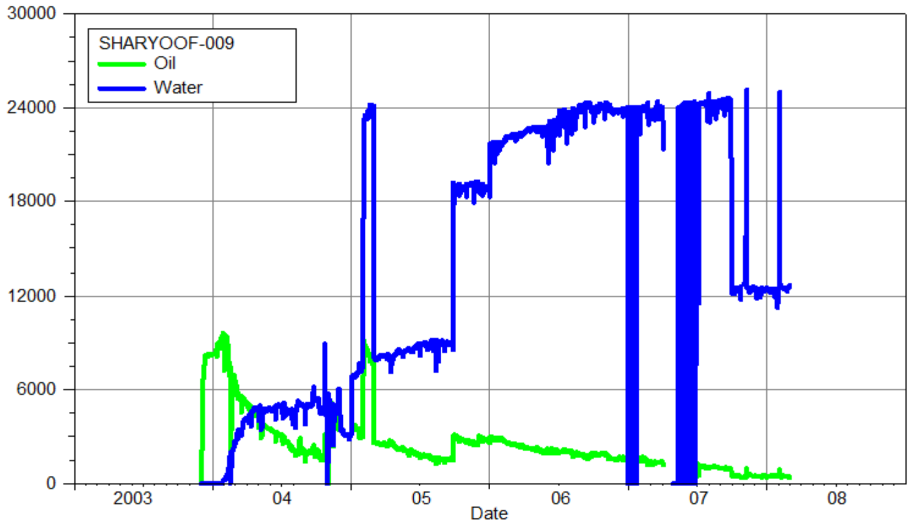


Fig 4.3 : Well production rate versus time (Well 009)

29-Oct-2004 Workover job was performed to replace the ESP. A new HR13500, 116 stages, ESP assembly was picked up and run on a new 5-1/2", 15.5 spf, BTC tubing string

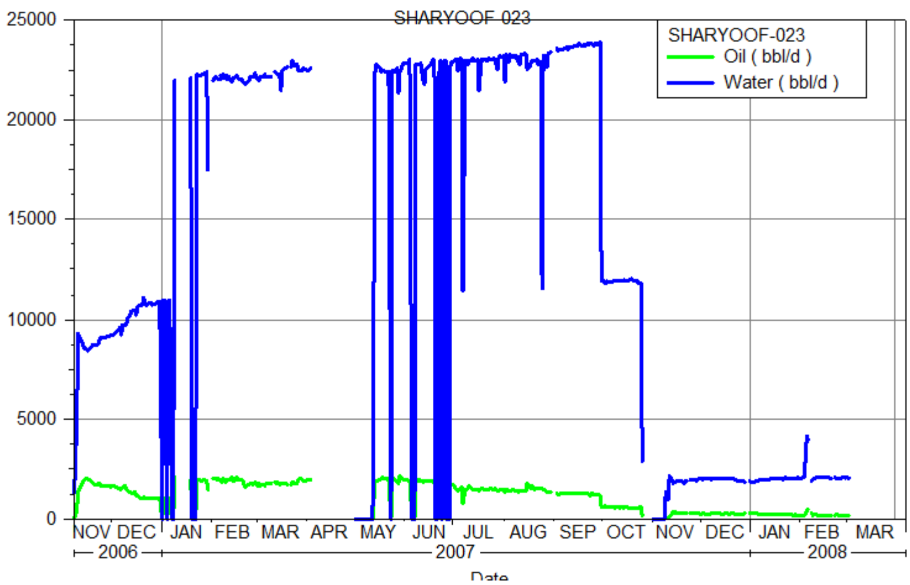


Fig 4.4 : Well production rate versus time (Well 023)

4.2.1 DIAGNOSIS OF SIMULATED RESERVOIR PRODUCTION PERFORMANCE:

Figures 4.5 through 4.7shows the trend of the simulated log-log plots of WOR and WOR' with time. Fig. 4.5 which is a field simulated plot, shows a positive slope for WOR and the WOR' plot is positive. From Fig 4.6 there is an increasing trend for WOR wearas WOR' first decline and then increase that mean in first of production there is coning then channeling is happened . Chan (1995) shows the diagnostic trends of reservoir related problems to have positive slopes for both WOR and WOR' for channelling and a positive and negative slope for WOR and WOR' respectively for coning. Fig 4.7 does not indicate the trends to conclude whether the water production is due to channelling or coning. It indicate that the reservoir is normal but when we compare time of production for this well with an bounded well we understand that is because start to produce in late time that means that the channeling is happened before in these area .

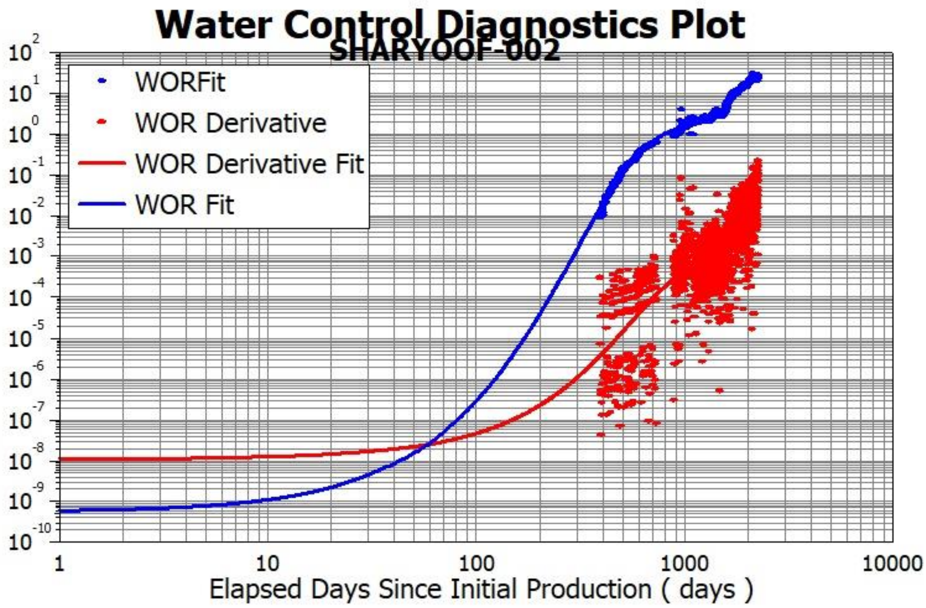


Fig 4.5: Well Diagnostic Plot (Well 002)

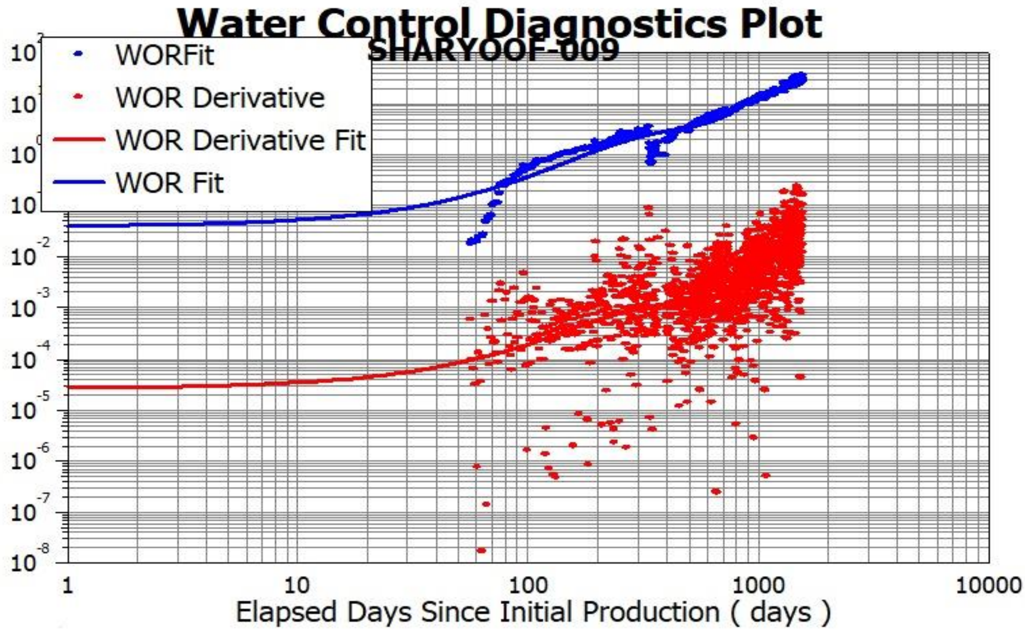


Fig 4.6: Well Diagnostic Plot (Well 0.09)

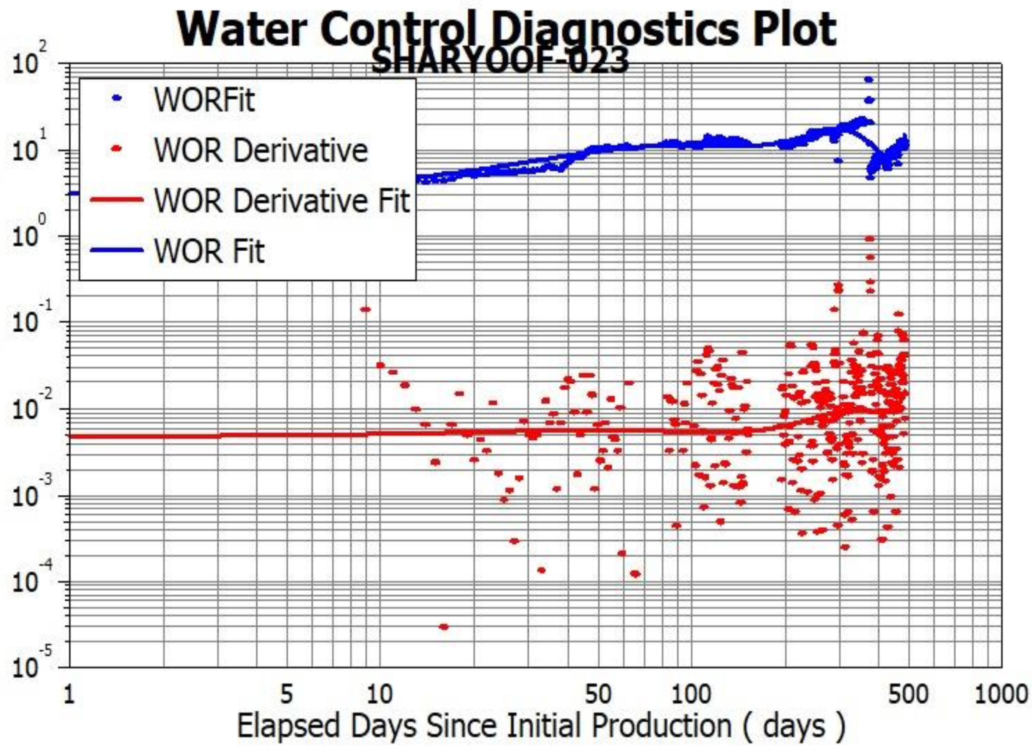


Fig 4.7: Well Diagnostic Plot (Well 0.23)

4.3 Water coning:

is movement of water upward into oil strata in response to production of oil and lower reservoir pressures. May be localized in areas of high vertical permeability.

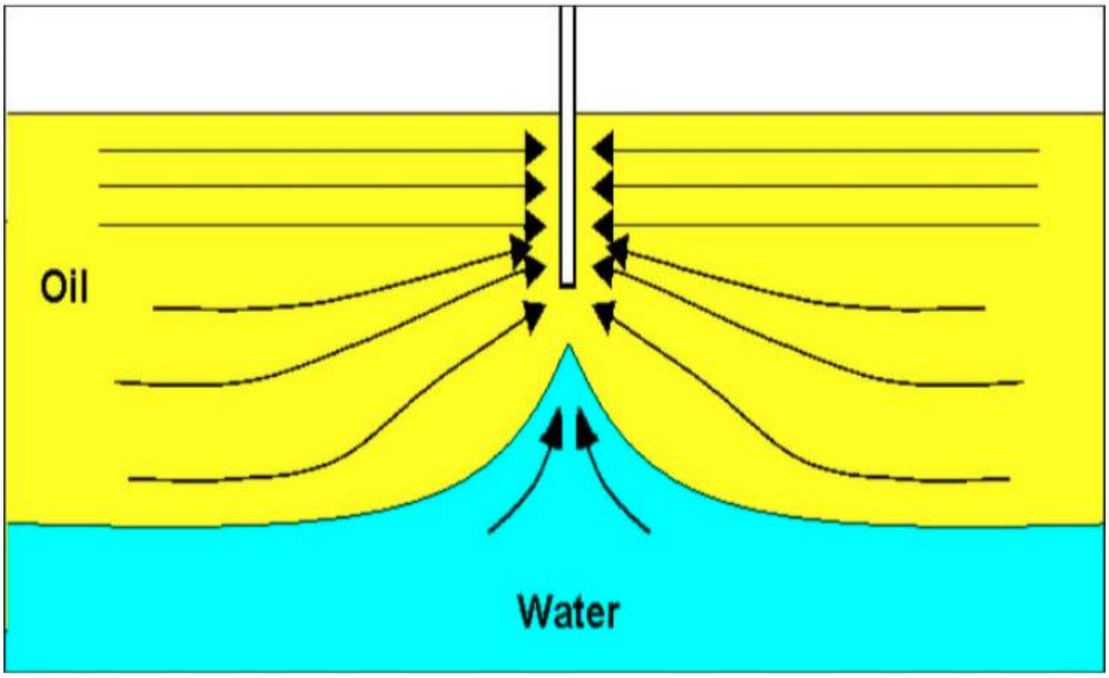


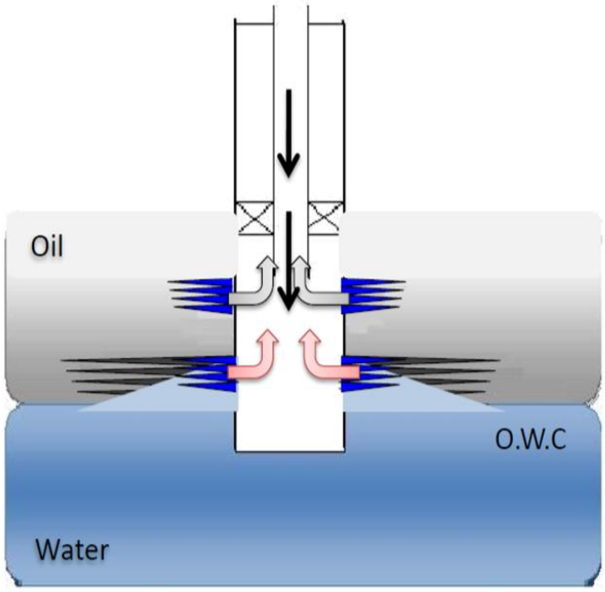
Fig4.8 Schematic of water coning into a well

4.3.1 Reasons of Water Coning

One of the primary factors leading to coning is pressure drawdown, another author said that the primary factor leading to coning is movement of reservoir fluids towards the zone of least resistance. Muscat and Wyckoff (1935) point out some significant reasons for coning as well. The first reason is that the pressure drop between the reservoir boundary and the points below the bottom of the well is greater than the hydrostatic head of the given water column. Second reason is related to viscous and gravity forces. The latter is associated with density difference between the oil and water. Gravity forces act in vertical direction and cause the fluid to rise due to density difference. At any time there is an equilibrium between viscous and gravity forces. Once this balance is destroyed, more specifically, when the viscous forces exceed the gravitational ones, cone will break into the well. On the other hand, if the pressure in the system is in unsteady state, the cone, which is now known as an unstable, will proceed towards the well until the steady-state condition is reached. The reason for water cone to become unstable is that upward dynamic force is extremely high and is not possible to balance with the weight of water below. . After knowing the reasons of water coning and diagnosis this problem we should find the breakthrough time and critical production rate by using correlation that have done by Sobocinski and Cornelius (1964), and Bournazel and Jeanson (1971) for breakthrough time and Chaperon (1986), Ozkan and Raghavan (1990), and Giger (1989) for critical production rate.

4.4 Channeling

Water channeling is common when high permeability layers or fractures allow early water breakthrough during waterflooding. Higher permeability streaks can allow fluid that is driving hydrocarbon production to breakthrough prematurely, bypassing potential production by leaving lower permeability intervals unswept. This is most common in active water-drive reservoirs and water floods. As the driving fluid sweeps the higher permeability intervals, permeability to subsequent flow of the fluid becomes even higher, which results in increasing water-oil ratios throughout the life of the well.



4.5 Solutions for the problems:

4.5.1 solution of coning by Squeeze cement

- Perforation at or close to OWC.
- Squeeze cement into the formation
- Formation of impermeable barriers.
- Not expensive and can use below short thickness oil pay

4.5.2 Solution of channeling by polymer:

Polymer Flooding

Another common technique for water shutoff operations is the usage of the polymer flooding method to increase the viscosity of the water. This technique is applied to increase the viscosity of the drive fluid (water) which helps in mobilizing and displacing the oil in the reservoir matrix rock. This technique is usually applied in the reservoir far from the production wells through water injection wells to achieve better sweeping efficiency in the reservoir. That eventually leads to preventing excessive water production. The usage of polymer flooding is very common among the oil operators and it can be prepared by dissolving the polymers in the injected water and inject it through injection wells. Polymers used in this technique are usually two types: biopolymers and synthetic polymers. Biopolymers' advantages over the synthetics are that they are not affected by the salinity of the water and they are insensitive to the mechanical degradations. However, they are more expensive than synthetic polymers so we will not use it.Synthetic polymers are more common since they are cheaper, more available, and perform well with low-salinity water. Polyacrylamide (PAM) and hydrolyzed polyacrylamide (HPAM) are two types of synthetic polymers. Polymers can also play a role in reducing the permeability if the molecular weight is increased Sydansk, D.and Romero-Zeron, L 2011]. Finally, based on the characteristics of the reservoir and the economics of the operations, the right polymer is chosen in case of chemical injection.we well use these type of polymer because it is not expensive and the salinity of water is not high salinity .

To do injection polymer to reservoir there are Screening Parameters

- Gravity > 18°API
- Viscosity < 200 cp
- Oil saturation > 10% PV mobile oil
- Formation type sandstone / carbonate
- Net thickness not critical
- Average permeability > 20 md
- Transmissibility not critical
- Depth < 9,000 feet
- Temperature <225 ° F

Sharyoof Reservoir properties is:

- Oil density = 31.5 API
- Oil Viscosity=4.5 cp
- Average permeability
- Depth < 9,000 feet
- Average permeability > 20 md

When we apply this Screening Parameters in Sharyoof field we conclude that we can apply polymer flooding in Sharyoof field.

CHAPTER 5

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 SUMMARY AND CONCLUSIONS

The objectives of this work are to understand field and wells performance and application of diagnostic plots to analyse water production problems.

This project applied Chan method and identified the reason of high excessive water production, The three wells located in sandstone reservoir with high vertical and horizontal permeability and high water saturation of the formation well set the conning phenomenon important reason of water production.

- The performance of sharyoof field and some individual well and it's event were exhibit in plots.
- The problem of multi-layered channelling was diagnosed.
- For effective evaluation of water production and injection behaviour of wells in a reservoir, there is need to verify the applicability of any of the available diagnostic methods to the particular field of interest. This would ensure that accurate diagnoses are derived to provide the necessary information for planning water management programmes in the field.

5.2 RECOMMENDATIONS

The following recommendations are presented for future research work to improve

the proposed methodology and results obtained in this study:

- A performance evaluation of water injection and sweep efficiency by for oil by water.
- A fine grid scale and more representative reservoir model should be built of the Case Study to conduct a history match of the production and injection data to improve the diagnostic procedure developed in this study.
- Apply multi scenario of polymer injection to increase ultimate recovery of oil

5.3 Limitations of our project

1-lacking of the real information.

2-Not having the opportunity to go to the location of wells and do some tests for the project.

3-the difficulty to obtain the required data.

4-Not having enough time to mention more details.

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SHARYOOF-002

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2358	5424	9/28/2003
2290	5242	9/29/2003
2374	5384	9/30/2003
2357	5346	10/1/2003
2342	5311	10/2/2003
2361	5330	10/3/2003
2368	5295	10/4/2003
2477	5411	10/5/2003
2404	5276	10/6/2003
2398	5119	10/7/2003
2407	5162	10/8/2003
2417	5207	10/9/2003
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2586	5087	11/5/2003
2666	5245	11/6/2003
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2704	5111	11/8/2003
2663	4989	11/9/2003
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4262	4811	6/13/2004
4283	4825	6/14/2004
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4459	4832	6/18/2004
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4666	4685	6/28/2004
4538	4744	6/29/2004
4576	4744	6/30/2004
4537	4722	7/1/2004

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4677	4772	7/3/2004
4728	4823	7/4/2004
4745	4861	7/5/2004
4761	4857	7/6/2004
4434	4578	7/7/2004
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4487	4614	7/12/2004
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4662	4552	7/15/2004
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4665	4500	7/17/2004
4685	4520	7/18/2004
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4638	4546	7/21/2004
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4709	4400	7/23/2004
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7263	2851	1/6/2005
7254	2850	1/7/2005
7218	2838	1/8/2005
7134	2852	1/9/2005

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7159	2858	1/11/2005
7128	2826	1/12/2005
7071	2886	1/13/2005
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7071	2969	1/15/2005
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8240	3599	1/28/2005
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8321	3680	1/31/2005
8327	3678	2/1/2005
8341	3677	2/2/2005
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8334	3728	2/4/2005
8313	3812	2/5/2005
8269	3849	2/6/2005
8279	3814	2/7/2005
8263	3806	2/8/2005
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8222	3902	2/10/2005
8294	3867	2/11/2005
8280	3891	2/12/2005
8360	3842	2/13/2005
8361	3907	2/14/2005
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8176	3907	2/19/2005
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8236	3930	2/21/2005
8253	3890	2/22/2005
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8182	3835	2/24/2005
8233	3827	2/25/2005
8183	3801	2/26/2005

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8056	3814	3/1/2005
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8244	3633	3/25/2005
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8176	3611	4/2/2005
8181	3635	4/3/2005
8175	3650	4/4/2005
8158	3622	4/5/2005
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7848	3444	4/7/2005
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8179	3567	4/9/2005
8158	3518	4/10/2005
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8190	3559	4/12/2005
8211	3532	4/13/2005
8188	3486	4/14/2005
8184	3502	4/15/2005

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8182	3516	4/17/2005
8096	3628	4/18/2005
8207	3542	4/19/2005
8194	3573	4/20/2005
8207	3535	4/21/2005
8192	3544	4/22/2005
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8222	3583	4/25/2005
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8176	3536	4/28/2005
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8232	3493	4/30/2005
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8227	3527	5/3/2005
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8232	3462	5/9/2005
8237	3447	5/10/2005
8253	3454	5/11/2005
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8357	3321	5/22/2005
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8784	3366	5/27/2005
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8861	3235	6/2/2005

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8791	3412	6/4/2005
8733	3524	6/5/2005
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8740	3515	6/7/2005
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9020	4173	7/31/2005
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8856	4061	8/24/2005
8870	4050	8/25/2005
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8874	4017	8/27/2005
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8892	3917	8/30/2005
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14394	576	1/18/2008
14435	566	1/19/2008
14433	546	1/20/2008
14431	561	1/21/2008
14451	584	1/22/2008
14570	555	1/23/2008
14564	567	1/24/2008

14574	550	1/25/2008
14581	562	1/26/2008
14558	554	1/27/2008
14592	561	1/28/2008
14591	565	1/29/2008
14592	544	1/30/2008
14604	563	1/31/2008
14619	547	2/1/2008
14617	570	2/2/2008
14603	579	2/3/2008
14532	568	2/4/2008
29046	1096	2/5/2008
29076	1090	2/6/2008
14646	518	2/8/2008
14521	565	2/9/2008
14597	527	2/10/2008
14489	588	2/11/2008
14444	617	2/12/2008
14504	623	2/14/2008
14555	575	2/15/2008
14634	532	2/16/2008
14576	572	2/17/2008
14404	691	2/18/2008
14628	553	2/19/2008
14532	581	2/20/2008
14488	580	2/21/2008
14594	596	2/23/2008
14786	504	2/24/2008
14519	634	2/25/2008
14593	622	2/26/2008
14684	537	2/27/2008
14770	531	2/28/2008
14664	600	2/29/2008
14693	578	3/1/2008
14762	524	3/2/2008
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