Sudan University of Science and Technology

College of Petroleum Engineering and Technology

Department of Petroleum Engineering

5th year

A final year project

Excess Water Production Diagnosis in a Sudanese Oil Field

By using WOR derivative method

تشخيص إنتاج الماء المتزايد في أحد حقول النفط السودانية باستخدام طريقة مشتقة نسبة الماء الى النفط

Project submitted to College of Petroleum Engineering & Technology in partial fulfillment of the requirements for the degree of B.Sc in Petroleum Engineering

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September 2014

Research about:

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This project is accepted by College of Petroleum Engineering and Technology to Department of Petroleum Engineering

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Date: / / 2014

الإستهلال

يقول الله تعالى :

بسم الله الرحمن الرحيم

﴿ وَقُلْ رَبِّ زِدْنِي عِلْماً ﴾

صدق الله العظيم

طه الآية ١١٤

Dedication

We would like to donate this unpretentious effort to

Our Parents;

Who have endless presence and for the never ending love and encouragement

Our brothers and sisters;

Who sustained us in our life and still

Our teachers;

Who lighted candle in our ways and provided us with light of knowledge

Finally; our best friends;

Our Classmates

Researchers…

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Thanking to Allah before and after...

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Finally; thanking to our teachers, colleagues and workers at College of Petroleum Engineering & Technology for their cooperation...

ABSTRACT

Excessive water production is one of the major problems in Sudanese oil fields.

The main purpose of this project is to diagnose the excessive water production mechanisms as case of a Sudanese oil field.

The diagnostic plots derivative method is applied using Microsoft Excel format on calculating and plotting the derivative response to understand the mechanisms that create the problem, considering seven examples of a Sudanese oil well's data. As a result of this research, channeling is the main reason for water production in five wells, and normal with high water cut is the other phenomenon for wells.

KEYWORDS: *excess water production problems, methods of diagnosing problems, diagnostic plots derivative method.*

التجريد

إن إنتاج المياه المتزايد من أكبر المشاكل التي تواجه حقول النفط السودانية على وجه العموم، لذلك يهدف هذا المشروع إلى تشخيص ومعرفة آلية إنتاج المياه في أحد الحقول السودانية.

لتحقيق هذا الهدف تم استخدام طريقة الرسم التفاضلية لنسبة الماء الى النفط (WOR derivative plots) باستخدام برنامج Microsoft Excel وذلك من بيانات الإنتاج لعدد سبعة آبار سودانية ، وقد وجد أن السبب الرئيسي لإنتاج المياه في خمسة آبار هو ظاهرة القنوات (channeling)، بينما في بقية الابار كانت المشكلة هي الزيادة العالية في نسبة المياه بصورة طبيعية (normal with high water cut).

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NOMENCLATURE

cum days	cumulative days
Q_O	oil production flowrate
Q_W	water production flowrate
stb/d	stock tank barrel per day
t	time
wc	water cut
WOR	water oil ratio
WOR'	derivative of water oil ratio

Chapter 1

Introduction

1.1. Excess water production in oil wells:

In petroleum production, a certain amount of water production is expected and sometimes even necessary in the initial phases of the life of the reservoir or well.

A petroleum engineer will have to be able to decide when water control solutions should be applied. If the costs associated with a water production rate still allow for an acceptable operating profit from produced oil or gas, that water production rate is considered acceptable. If the costs associated with a water production rate are too high to allow for an acceptable operating profit margin, the water rate is considered excessive.

Excessive water production can be caused by the natural depletion of a reservoir where an active water drive (either natural or artificial) has simply swept away most of the oil that the reservoir can produce, and there is little left to produce but water.

The best completions and production practices can delay, but not stop this water production. Most cases where water production rates have become a problem could have been avoided or delayed. Understanding reservoir behavior provides a basis for determining whether excessive water production is a concern and to determine if current water production is excessive.

Excessive water production is one of the major technical, environmental, and economical problems associated with oil and gas production. Water production can limit the productive life of the oil and gas wells and can cause severe problems including corrosion of tubular, fines migration, and hydrostatic loading. Produced water represents the largest waste stream associated with oil and gas production. The environmental impact of handling, treating, and disposing of the produced water can seriously affect the profitability of oil and gas production.

Reservoir rocks normally contain both petroleum hydrocarbons and connate water. Once the production starts, this water call 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 also injected into the reservoir to provide further pressure to the hydrocarbon reserves to move towards to 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 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.

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.

1.2. Water sources:

When it comes to producing oil a key issue is the distinction between sweep, good (acceptable), and bad (excess) water.

1.2.1. Sweep water:

It come from either an injection well or an active aquifer that is controlling 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.

1.2.2. Good water:

This is water that is produced into the well bore at a rate below the water /oil ratio (WOR) economic limit. It is an inevitable consequence of water flow through the reservoir and it cannot be shut off without losing reservoir.

Good water production occurs when the flow of oil and water is commingled through the formation matrix the fractional water flow is dictated by the natural mixing behavior that gradually increases the WOR.

Other form of acceptable water production is caused by converging flow lines into the well bore for example in one quadrant of a five spot injection pattern an injector feeds a producer, Flow from injector can be characterized by an infinite series of flow lines the shortest is a straight line from injector to producer and longest follows the on flow boundaries from injector to producer.

1.2.3. Bad water:

It can be defined as water that is produced into the well bore and produces no oil or insufficient oil to pay for the cost of handling the water-water that is produced above the WOR economic limit.

1.3. The objectives of research:

The objectives of this research can be summarized as follows:

1. Study different diagnostic techniques of excessive water production to find out the practical and feasible one of these techniques as a function of the accuracy for the water source identification.

2. Applied most appropriate method of diagnosis of excess water production problems.

3. Make a comparison analysis between the diagnostic results of water production problems achieved by the derivative method.

Chapter 2

Literature review and Theoretical Background

2.1. Literature review:

Different techniques have been developed to shut off or minimize excessive water production and the success of any of these techniques is a function of the accuracy of the water source identification.

Ershaghi et al (1987) introduced the so called “X –Plots” used to interpret and extrapolate water/oil production. The X plots were developed from a one dimensional Buckley Leverett simulation and has been applied successfully in the field to evaluate production efficiency. A major shortcoming with the X plot is that it does not give any diagnostic information on the source of water production.

One of the most widely used methodology for diagnosing the source of water using log-log plots of water oil ratio and water oil ratio derivative (WOR/WOR') versus time is due to Chan (1995). Chan developed his plots using numerical simulation to investigate the behavior of WOR/WOR' versus time under different mechanisms of production. For the different mechanisms investigated, the plots had characteristic trend which was used to diagnose the water source. These plots actually matched simulated results but when applied to field cases, the effect of noise made it difficult to carry out a good decision.

Novotny (1995) developed a methodology for diagnosing the possible source of water production using production data and Darcy flow equation. Novotny based his diagnosis on the magnitude of the change in the calculated value of the absolute permeability of the formation using oil/water relative permeability values obtained from a representative oil/water relative permeability relation for the reservoir. This form of diagnosis was based entirely on calculated absolute permeability and did not take into account the observed time series and highly dependent on the availability of “reliable” relative permeability relation for the reservoir.

Using analytical and numerical studies of water flooding under a variety of conditions, Yortsos et al (1999) showed that the late time slope of Chan’s diagnostic log-log plot could be related to the well pattern and relative permeability characteristic of the reservoir. They conducted their studies in one, two and three dimensions and were able to show that the “X plot” is a special case of the 1-D displacement at intermediate time. Though the work by Chan and Yortsos et al are to date, one of the best technique for diagnosing the possible source or origin of produced water, it is still affected by noise since the analyses were conducted in the time domain.

Egbe and Appah (2005) proposed a model for diagnosing water coning problem in oil wells using spectral analysis of production data. They based their work on a modification of WOR plots in which they used Fourier transformation to convert surface WOR from time domain to a spectrum of frequencies. They used autocovariance function and the spectral density function to obtain information about the spectral bandwidth, the correlation structure and energy distribution for coning and non-coning mechanisms. They concluded that wells with coning problem represented periodic spectrums with narrow spectral width.

Applicability of WOR plots for excess water production diagnosis in horizontal wells was investigated by Al Hasani et al (2008). They used simulation models to examine the behavior of WOR plots in water coning and water channeling problems in vertical and horizontal wells. They reported that the WOR trends in their simulated models were in agreement with Chan's diagnostic plots and concluded that these plots could be used for problem identification in horizontal wells.

Gasbarri et al (2008) proposed a diagnosis technique using transient test and multiphase flow meters. They used reservoir simulations to build three base cases of water production mechanism models of coning, water channeling and flow behind casing. With different ranges of production rate, API gravity, permeability ratio and diameter of the flow channel behind casing were used to generate various instances of the mentioned base cases.

In a recent work by Ayeni (2008) an empirical method was developed for modeling and predicting edge–water coning problem. He ran a number of reservoir simulations by varying different model variables from which he derived empirical correlations between reservoir characteristics and model parameters. These empirical correlations were suggested for estimation of critical flow rate, breakthrough time and WOR performance after water breakthrough.

M.Rabiei et al (2009) applies a Meta learning classification technique called Logistic Model Trees (LMT) to diagnose water production mechanisms based on WOR data and static reservoir parameters. Synthetic reservoir models are built to simulate excess water production due to coning, channeling and gravity segregated flows. Various cases are then generated by varying some of the input parameters in each model. A number of key features from plots of WOR against oil recovery factor are heuristically extracted by segmenting these plots at certain points. LMT classifiers are then applied to integrate these features with reservoir parameters to build classification models for predicting the water production mechanism in different scenarios of pre and post water-production stages.

Reyes et al (2010) use operational reliability and optimization six sigma tools to establish cause-and-effect relationship between production of water, reservoir characteristics and configuration of wells. These relationships are used to determine the corresponding effects of Water Production Mechanism. For identification of water production origin they first review the key variables used to model typical oil wells including the volume of produced fluids, water injection, WOR, water cut, mobility ratio, reservoir pressure, wellhead pressure, pressure drop at drainage area, injectivity index, remaining reserves, oil prices, water production cost, reservoir depletion, water invasion and effect of specific gravity. Then, they use casual loop diagrams for modeling cause and effect relationships.

M.Tabatabaei et al (2011) present methodologies for interpreting numerous conditions in wells from temperature profiles. The most fundamental well property that can often be obtained from a temperature profile is the well's inflow profile. They illustrate how such water or gas inflows can be quantitatively identified by applying standard inversion methods to the measured temperature profiles, yielding the locations and rates of water or gas entries. This method can be applied before a stimulation treatment to aid the stimulation design, or post-job to evaluate treatment results.

Concerning the application of the diagnostic plots derivative method, Elradi Abass and Satti Merghany (2011) prepared a paper which provided a simplified computation and quick technique for engineers; by using Microsoft Excel format on calculating and plotting the derivative response, considering two case examples of a Sudanese oil well's data.

2.2. Excess Water Production Problems:

Water production causes can be divided into several categories including mechanical, completion related, and reservoir related problems.

2.2.1. Mechanical Problems :

Poor mechanical integrity of casing, tubing, and packers such as holes from corrosion, wear and splits due to flow, excessive pressure, or formation deformation contribute to leaks.

Leaks result in unwanted entry of water and unexpected rise in water production. In addition, the water entry in the wellbore can cause damage to the producing formation due to fluid invasion.

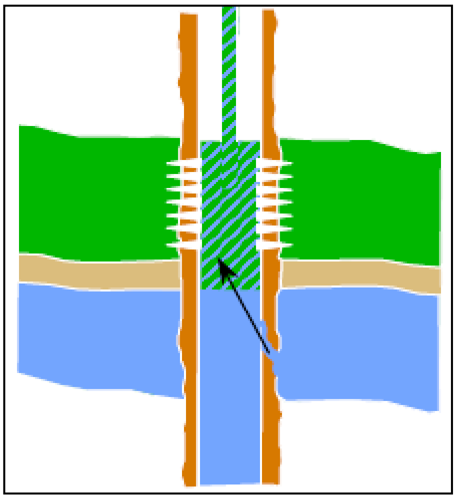

Figure 2.1: Tubing, casing and packer leaks (After Elphick and Seright 1997)

2.2.2. Completion related problems :

The common completion related problems are flow behind casing, completion into or close to water zone, and fracturing out of zone.

Poor bonding between cement–casing or cement–formation can cause unwanted water to flow behind casing and enter the well. Completion into or close to water zone leads to immediate production of water. Sometimes stimulation attempts can cause the natural barriers between hydrocarbon bearing layers and water saturated zones to heave and fracture near wellbore, allowing the water to migrate to the wellbore.

2.2.2.1. Flow behind casing :

Failed primary cementing can connect water-bearing zones to the pay zone. These channels allow water to flow behind casing in annulus. A secondary cause is creation of a 'void' behind the casing as sand is produced. It can develop throughout the life of well, but are most likely to occur immediately after the well is completed or stimulated.

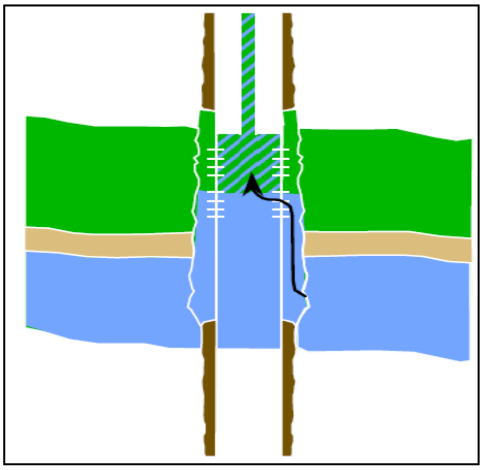

Figure 2.2: Flow behind casing (After Elphick and Seright 1997)

2.2.2.2. Moving 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.

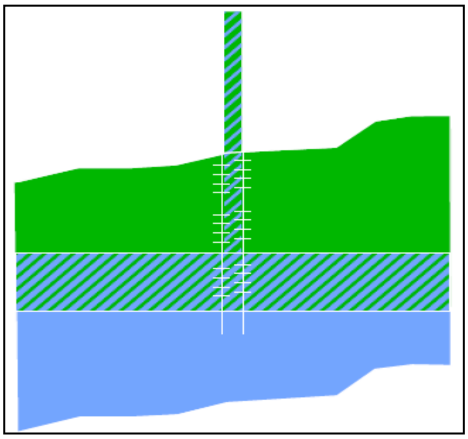

Figure 2.3: Moving oil-water contact (After Elphick and Seright 1997)

2.2.2.3. Fissures or fractures from a water layer :

Water is produced from an underlying water zone through natural fissure. A similar problem results when hydraulic fractures penetrate vertically into a water layer. The application of shutoff fluids may be effective for this problem.

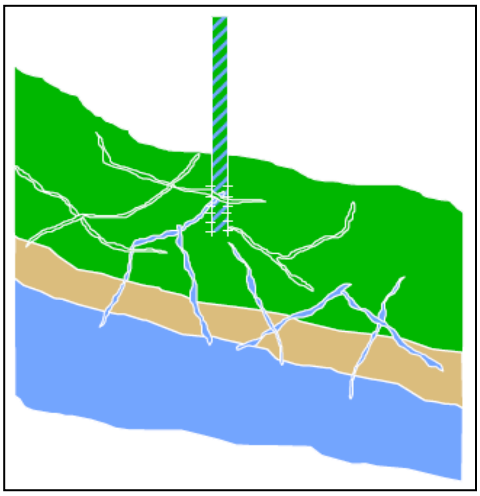

Figure 2.4: Fissures/fractures from a water layer (After Elphick and Seright 1997)

2.2.3. Reservoir related problems :

Water channeling through high permeability layers or fractures and faults and water coning from an adjacent water zone are major reservoir related problems. Heterogeneities in the reservoir are one of the main causes of excess water production in oil fields.

2.2.3.1. Channeling :

Water channeling is caused by reservoir heterogeneities that lead to presence of high permeability steaks. Fractures or fracture-like features are the most common cause of the channeling. Water production could emanate via natural fractures from underlying aquifer. Induced or natural fracture fractures can cause channeling between wells. In un fractured reservoir often stratification and associated permeability variations among various layers can result in channeling between an injector and producer or from an edge water aquifer to the producers. Deviated and horizontal wells are prone to intersect faults or fractures.

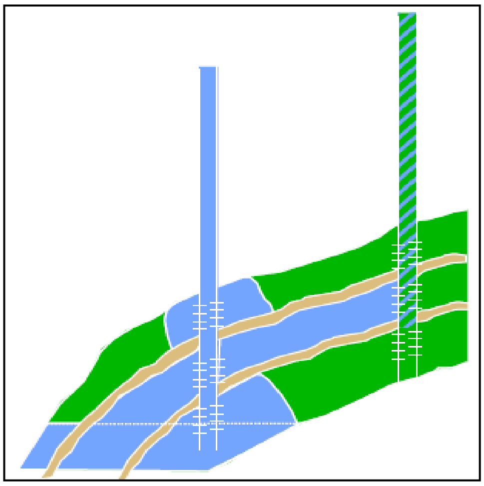

Figure 2.5: Channeling through high permeability layers (After Elphick and Seright 1997)

2.2.3.2. Coning :

Water coning is caused by vertical pressure gradient near the well. The well is produced so rapidly that viscous forces overcome gravity forces and draw the water from a lower connected zone toward the wellbore. Eventually, the water can break through into the perforated or open-hole section, replacing all or of the hydrocarbon production. Once breakthrough occurs, the production tends to get worse, as higher cuts of the water are produced. Although reduced production rates can curtail the problem, they cannot cure it. Cusping, in an inclined zone up to a vertical well, and water cresting in horizontal wells are similar phenomena to water conning.

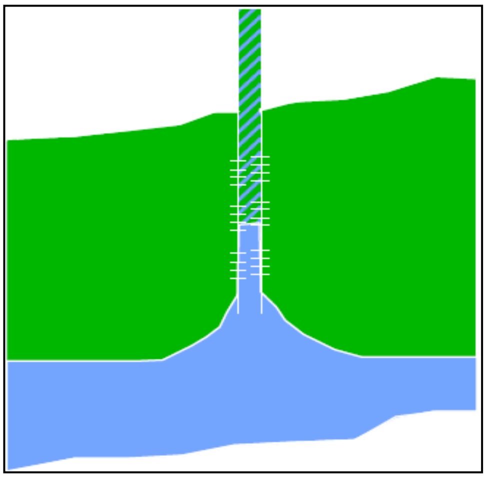

Figure 2.6: Water coning (After Elphick and Seright 1997)

The reservoir related problems of coning and channeling are the two major causes of excess water production in oil wells.

2.2.3.3. Fracture Communication Between Injector and Producer:

Natural fractures can provide a direct link between an injector and a producer, allowing the water to flow primarily through these high-permeability channels, and bypass oil within the adjacent rock matrix.

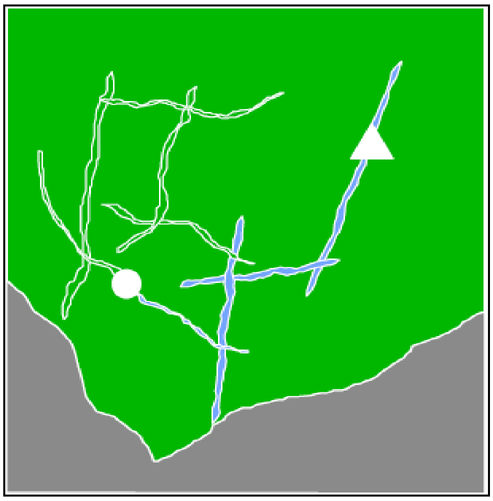

Figure 2.7: Fractures between injector and producer (After Elphick and Seright 1997)

Chapter 3

The Research Methodology

3.1. Methods of Diagnosing Problems:

It is common industrial practice to use well diagnostics to determine the existence of excess water production, locating the water entry point in the well and choosing the candidate wells to perform treatment methods, whereas appropriate selection of the water control technology depends on the correct identification and diagnosis of the water production problem source. Hence water production problems often are not properly diagnosed.

Conventionally, information such as production data, and various logging measurements are used in well diagnostic applications. This information is also used in deciding whether any remedial action needs to be taken. Fondyga (2008), Reynolds (2003) and Bailey et al. (2000), have provided reviews on available diagnostic tools and techniques used for identifying water production mechanisms in wellbore.

Generally these techniques can be categorized into two groups:

The first group mainly includes logging and survey tools for evaluating and monitoring the physical conditions of the well, reservoir and fluid flows. Radioactive tracer logs, temperature logs, spinner (flow meter) logs, cased hole formation resistivity (CHFR) tool, pulsed neutron, thermal decay time tool, reservoir saturation tool, pressure testing, casing inspection logs and chloride/total dissolved solids (TDS) test are few examples of various available well testing tools and techniques. The use of such tools and techniques can provide some insights into the water production mechanism encountered in the well. Except in very limited situations, well logging tools lack the ability to diagnose the type of the water production mechanism.

The second group consists of various analytical and empirical techniques based on production data. They are the most commonly used for investigating the overall performance of the reservoir as well as individual wells. The key elements of the production data are the information on the rate of the produced oil and water, collected at regular time intervals (usually on a daily basis). Usually, along with the rates of the produced oil and water, the ratio of the produced water to the produced oil (WOR), is also used for interpretation and production analysis. Production data analyses by means of analytical and empirical techniques such as decline curve plots, and water-oil ratio

(WOR) versus cumulative oil production or time is a widely explored subject in the literature. There are also other less common techniques for water production mechanism diagnostics based on reservoir and fluid characteristics.

In fact, incorrect, inadequate, or lack of diagnoses has been cited as one of the major reasons that water control treatments have been ineffective.

Proper diagnostic techniques significantly enhance success of traditional treatments, both technically and commercially.

Identifying the source of excess produced water is important because water coning or channeling can seriously impact the oil productivity because relative permeability effects. In the other hand, lifting cost rise with introduce heavier wellbore fluids and artificial lift needed. Furthermore, increasing produced water will result in additional cost for expanding water handling capacity for treatment and disposal. Also, additional cost will added for solving corrosion problems.

Delaying the encroachment of water is essentially the controlling factor in maximizing the field's ultimate oil recovery. Early identifying of production mechanism has an important influence on operations, recovery and economics.

3.2. Diagnostic plots derivative method:

Using Water/oil ratio (WOR) diagnostic plots which prepared by Chan (1995).A set of diagnostic plots is generated by conducting a series of systematic water-control numerical simulation studies using a black oil simulator. This three-dimensional, three phase simulator is capable of modeling the performance of reservoir flow under different drive mechanisms and water flood schemes.

According to this method, a log-log plot of WOR versus time will show different behavior for the varying mechanisms.

Log-log plots of WOR time derivatives versus time are said to be capable of differentiating whether a production well is experiencing water coning, channeling due to high-permeability layers, or normal with high water cut.

The Derivative method can be considered as the most appropriate methodology for identifying the source of the water production problems. Therefore this method is considered as a unique technique and has been proposed as an easy, fast, and inexpensive method to identify excessive water and gas production mechanisms.

The method for differentiating and diagnosing water problems is expressed as below:

By using Microsoft Excel format on calculating and plotting the derivative response.

First, the value of water/oil ratio (WOR) is calculated by using the actual oil and water production, and the equation is:

$$WOR = \frac{Q_w}{Q_o} \quad (3.1)$$

Then, the derivative value of water/oil ratio (WOR) is calculated by the following equation:

$$WOR' = \frac{d(WOR)}{dt} = \frac{(WOR_2 - WOR_1)}{(t_2 - t_1)} \quad (3.2)$$

Finally, the water problem is diagnosed with the help of table 3.1.

Table 3.1: different patterns source of producing water in the reservoir

WOR Slope	**WOR' Slope**	**Reason for Water Production**
positive	Positive	Channeling
positive	Negative	Coning
Positive linear slope	horizontal line	water/oil contact rising

The verification made by comparison result with standard diagnostic plot of Chan. The plots for the 3 water problems are illustrated in the following figures:

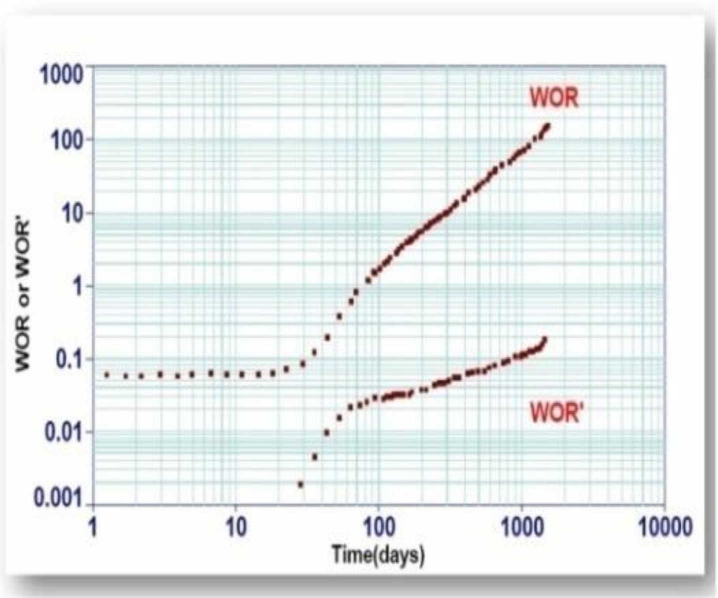

Figure 3.1: Channeling, WOR & WOR' derivatives (After Chan, K.S. 1995)

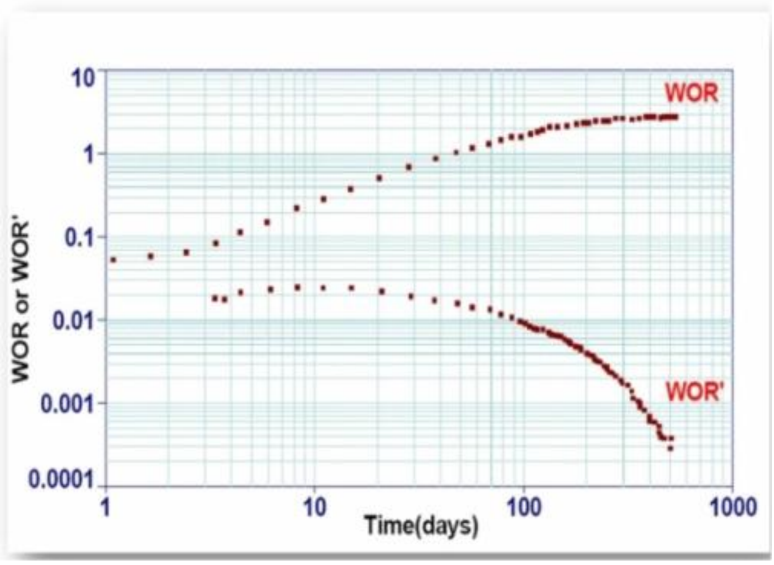

Figure 3.2: water coning, WOR & WOR' derivatives (After Chan, K.S. 1995)

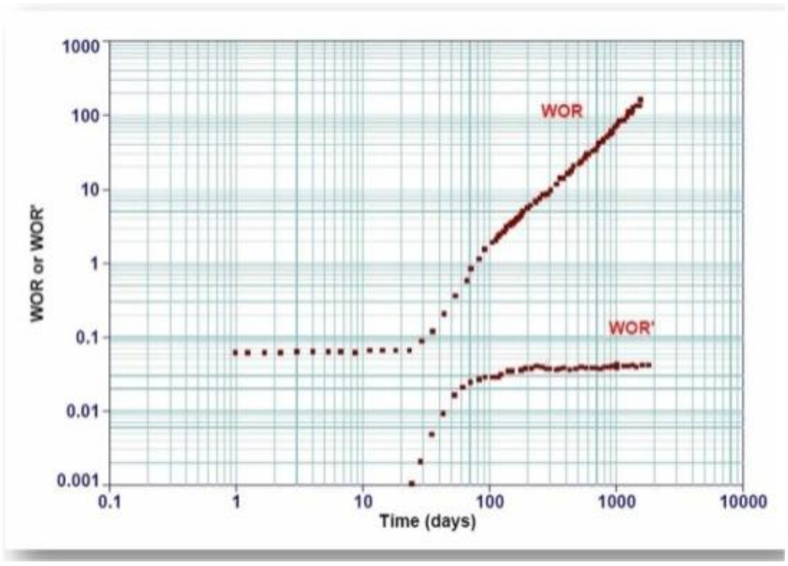

Figure 3.3: Water/oil contact rising (After Chan, K.S. 1995)

Then obtaining the necessary production information and diagnosing for the reason of water production.

For coning, the rate of the WOR increase is relatively slow and gradually. For channeling, the water production increases quickly depending on the relative permeability functions.

The time derivative of WOR can be used to differentiate coning from channeling. A constant positive slope is indication for water channeling, where a changing negative slope is an indication for water coning.

From the actual production history data, log-log plots of WOR and WOR derivative versus time were generated. These plots give a picture of past and current production behaviors.

This method can be an effective tool for the selecting of water control treatment candidates, since there is a different job design for different mechanism.

3.3. The advantages of derivative method:

1. It mainly uses available production history data.
2. It can be used to rapidly screen a great number of wells.
3. It entails the best reservoir engineering principles and practices.
4. It could yield results to form the basis for conducting a production mechanism survey, compare mechanisms between adjacent wells, good production wells versus problematic production wells, and by area or by well pattern.
5. With the WOR versus cumulative oil production plot and the oil rate decline curves, it would become an effective methodology to select candidate wells for water control treatments.

3.4. The disadvantages of derivative method:

1. The diagnostic plots showed a random and noisy trend on both the WOR and WOR' plots, hence they provide a controversial basis for characterizing water production based on surface observation of production trend.
2. The derivative method can't valid for all cases because of WOR and its derivatives are plotted versus time, not versus dimensionless time. Dimensionless groups are commonly used to generalize problems or plots, e.g., type curves in well testing.
3. Multi-layer channeling problems can easily be mistaken as bottom water coning, and vice versa, if WOR diagnostic plots are used alone to identify an excessive water production mechanism.

Chapter 4

Results and Discussion

4.1. Case study background:

The targeted wells for this study from southwest field which is one of the seventh structures that creating Sudan southwest oil fields. The main formations are Bentiu and Abu Gabra.

Currently the field production rate is about 20,000 STB/D to the FPF (Field production Facility) with 60 % water cut due to the high production rate of the wells. Almost 11 of wells are active and 11 are shutdown 5 of them due to high water cut and three wells converted to water injectors.

The production history of the field shows a huge improvement after applying the gas Huff &Puff techniques .Gas lift is implemented after the huge drop of Abu Gabra gas pool pressure in order to keep the production sustain. Currently the field using the nitrogen as a source of high pressures to unload the wells. Water production increased rapidly throws the life of the field.

4.2. Well selection methodology

1. High production rate with a good cumulative production history
2. High thickness and good location on the sand contour map is an excellent candidate
3. Recoverable reserves with a water cut range of 80 to 95 %.

4.3. Discussion:

Concerning the application of the diagnostic plots derivative methods to the targeted data mentioned in chapter 3, the study provides an example for seven oil wells. Using Microsoft Excel format, the production data and a simplified computation WOR derivative given in tables from (4-1) to (4-7).

Figures from (4-1) through (4-5) show examples for water channeling wells with positive slope which indicate to high horizontal permeability.

Commonly the diagnostic plot figures show the WOR increasing with time. The rate of increase differs for a different problem mechanism. The degree of sharp or gradual rate of increase presents a signal difference between coning and channeling. The other mechanisms can be recognized through derivative response.

Figure (4-1) shows that the water displacement process appeared to be quite normal, after (250) days the rate of increase of the WOR is relatively fast approached a constant value at the end of this period. During this time since WOR derivative versus time showed a positive slope indicating initiation of water channeling.

Figure (4-2) showed that for well (2) started to produce and until (40) days left the WOR is very low indicating that most percentage of fluids produced are oil. After (350) days the rate of increase of the WOR is relatively fast and gradually approached a constant value at the end of this period. During this time since WOR derivative versus time showed a positive slope indicating initiation of water channeling.

Figure (4-3) showed that until (130) days left the WOR is very low indicating that most percentage of fluids produced are oil as the beginning of production of well (3). After (400) days water cut increased and rate of increase of the WOR is approached a constant value at the end of this period. The WOR plots show a linear and positive slope, characteristics of a water channeling case.

Comparing Figure (4-4) and (4-5) showed that there are difference in WOR' slope according to the degree of sharp or gradual rate of increase, in spite of The WOR plots show a linear and positive slope, characteristics of a water channeling case.

From Figure (4-6), the initial WOR was very high. The reason could be a high initial water saturation. Waterflood started in this well at about (700) days. The overall WOR trend shows a linear slope indicative of a normal displacement with high water cut.

Figure (4-7) has same description for figure (4-6), the slope indicative of a normal with high water cut behavior. The reservoir may be depleted because of high increase of water cut.

Wells (6) and (7) may be shut down or could convert into an injection wells which may be having an effect on economic side.

4.4. The Analysis results:

Reservoir is the kind of sandstone with high vertical and horizontal permeability, high water saturation, set the channeling phenomenon as the main reason of watery wells.

Reservoir depletion may be occur when water cut increase until hundred percent with zero oil production.

Table 4.1: production data and computation of WOR and WOR' - well (1)

DATE	Time Days	Cum Days	Q_o stb/d	Q_w stb/d	WC %	WOR	WOR'
30-Nov-10	30	30	7732.57	0.00	0.00	0.00000	0.00000
31-Dec-10	31	61	6650.22	8.08	0.12	0.00121	0.000039
31-Jan-11	31	92	4827.97	3.64	0.08	0.00075	
28-Feb-11	28	120	4249.49	9.42	0.22	0.00222	0.000052
31-Mar-11	31	151	4572.63	26.21	0.57	0.00573	0.000113
30-Apr-11	30	181	2486.82	3.18	0.13	0.00128	
31-May-11	31	212	4064.65	5.87	0.14	0.00144	0.000005
30-Jun-11	30	242	3398.86	16.87	0.49	0.00496	0.000117
31-Jul-11	31	273	3110.25	96.89	3.02	0.03115	0.000845
31-Aug-11	31	304	3639.97	0.00	0.00	0.00000	
30-Sep-11	30	334	91.67	0.00	0.00	0.00000	0.000000
31-Oct-11	31	365	3535.87	3.94	0.11	0.00111	0.000036
30-Nov-11	30	395	4966.39	5.64	0.11	0.00114	0.000001
31-Dec-11	31	426	4911.15	5.82	0.12	0.00119	0.000002
31-Jan-12	31	457	4562.16	0.78	0.02	0.00017	
29-Feb-12	29	486	3060.49	4.96	0.16	0.00162	0.000050
31-Mar-12	31	517	3222.80	25.58	0.79	0.00794	0.000204
30-Apr-12	30	547	2379.26	14.77	0.62	0.00621	
31-May-12	31	578	831.28	15.59	1.84	0.01875	0.000405
30-Jun-12	30	608	0.00	0.00	0.00	0.00000	
31-Jul-12	31	639	2165.92	1.21	0.06	0.00056	0.000018
31-Aug-12	31	670	3721.97	0.00	0.00	0.00000	
30-Sep-12	30	700	3478.57	0.00	0.00	0.00000	0.000000
31-Oct-12	31	731	3593.32	67.98	1.86	0.01892	0.000610
30-Nov-12	30	761	3845.69	120.32	3.03	0.03129	0.000412
31-Dec-12	31	792	3955.77	187.46	4.52	0.04739	0.000519
31-Jan-13	31	823	3499.50	231.73	6.21	0.06622	0.000607
28-Feb-13	28	851	2936.71	349.00	10.62	0.11884	0.001879
30-Mar-13	30	881	1655.50	56.20	3.28	0.03395	
30-Apr-13	30	911	13473.81	1121.75	7.69	0.08325	0.001644
31-May-13	31	942	9115.55	1962.81	17.72	0.21533	0.004260
30-Jun-13	30	972	7932.19	2683.14	25.28	0.33826	0.004098
31-Jul-13	31	1003	6436.61	2682.62	29.42	0.41677	0.002533
31-Aug-13	31	1034	5817.14	2854.83	32.92	0.49076	0.002387
30-Sep-13	30	1064	6270.49	2583.75	29.18	0.41205	
31-Oct-13	31	1095	6831.31	3596.72	34.49	0.52651	0.003692
30-Nov-13	30	1125	6278.44	3821.79	37.84	0.60872	0.002740
31-Dec-13	31	1156	7104.06	5303.90	42.75	0.74660	0.004448
31-Jan-14	31	1187	6093.30	5580.24	47.80	0.91580	0.005458

Table 4.2: production data and computation of WOR and WOR' - well (2)

DATE	Time Days	Cum Days	Q_o stb/d	Q_w stb/d	WC %	WOR	WOR'
31-Jul-10	4	4	341.75	2	0.581818	0.005852	0.0000
31-Aug-10	31	34	845.5484	13.74194	1.599219	0.016252	0.000335
30-Sep-10	30	64	226.1667	1.9	0.83309	0.008401	
31-Oct-10	31	95	720.9032	0.580645	0.080479	0.000805	
30-Nov-10	30	125	830.8667	0.7	0.084178	0.000842	0.000001
31-Dec-10	31	156	741.9677	0.290323	0.039113	0.000391	
31-Jan-11	31	187	0	0	0	0	
28-Feb-11	28	215	0	0	0	0	0.000000
31-Mar-11	31	246	9.032258	0	0	0	0.000000
30-Apr-11	30	276	341.9333	0.066667	0.019493	0.000195	0.000006
31-May-11	31	307	2321.645	0.935484	0.040278	0.000403	0.000007
30-Jun-11	30	337	2618.3	204.6333	7.248961	0.078155	0.002592
31-Jul-11	31	368	2640.903	370.9032	12.31498	0.140446	0.002009
31-Aug-11	31	399	3284.419	794.8387	19.48488	0.242003	0.003276
30-Sep-11	30	429	1535.133	702.6667	31.39989	0.457724	0.007191
31-Oct-11	31	460	1275.71	650.0645	33.75601	0.509571	0.001672
30-Nov-11	30	490	1279.233	755.2333	37.12193	0.59038	0.002694
31-Dec-11	31	521	1194.065	904.0323	43.08821	0.757105	0.005378
31-Jan-12	31	552	1150.903	1000.516	46.50493	0.869331	0.003620
29-Feb-12	29	581	856.6897	1338.034	60.96595	1.561866	0.023881
31-Mar-12	31	612	531.7419	1704.613	76.22283	3.205715	0.053027
30-Apr-12	30	642	730.3333	1428.8	66.1747	1.956367	
31-May-12	31	673	714.1613	1351.742	65.43104	1.892768	
30-Jun-12	30	703	666.8333	1515.467	69.44355	2.272632	0.012662
31-Jul-12	31	734	734.8387	1454.968	66.44276	1.979982	
31-Aug-12	31	765	845.7419	1394.258	62.24366	1.648562	
30-Sep-12	30	795	953.3667	1432.5	60.04108	1.50257	
31-Oct-12	31	826	940.5161	2089.258	68.95755	2.221395	0.023188
30-Nov-12	30	856	870.7333	2216.5	71.79567	2.545555	0.010805
31-Dec-12	31	887	852.4839	2201.774	72.08868	2.582775	0.001201
31-Jan-13	31	918	786.9032	2167.097	73.36143	2.753956	0.005522
28-Feb-13	28	946	843.4286	2122.357	71.56138	2.516345	
30-Mar-13	30	976	714.6667	1833.9	71.95809	2.566091	0.001658
30-Apr-13	30	1007	846.4333	2285.533	72.97438	2.700193	0.004470
31-May-13	31	1038	842.0323	2624.032	75.70639	3.116308	0.013423
30-Jun-13	30	1068	760.8	3101.567	80.30223	4.076717	0.032014
31-Jul-13	31	1099	672.129	2961.774	81.50394	4.406556	0.010640
31-Aug-13	31	1130	406.9032	3059.548	88.26168	7.519106	0.100405
30-Sep-13	30	1160	528.5333	2212.167	80.71539	4.185482	
31-Oct-13	31	1191	547.9677	2256.806	80.46304	4.118502	

Table 4.3: production data and computation of WOR and WOR' - well (3)

DATE	Time Days	Cum Days	Qo stb/d	Qw stb/d	WC %	WOR	WOR'
31-Dec-10	4	4	0	0	0	0	0.00000
31-Jan-11	31	34	0	0	0	0	0.000000
28-Feb-11	28	62	0	0	0	0	0.000000
31-Mar-11	31	93	2018.774	0	0	0	0.000000
30-Apr-11	30	123	1679.567	2.1	0.124876	0.00125	0.000042
31-May-11	31	154	2666.839	1.387097	0.051986	0.00052	
30-Jun-11	30	184	3265.633	0	0	0	
31-Jul-11	31	215	3656.258	2.645161	0.072294	0.000723	0.000023
31-Aug-11	31	246	4364.871	0	0	0	
30-Sep-11	30	276	3155.933	0	0	0	0.000000
31-Oct-11	31	307	4366	16.64516	0.379797	0.003812	0.000123
30-Nov-11	30	337	4567.2	115.3	2.46236	0.025245	0.000714
31-Dec-11	31	368	4270.032	281.1613	6.177748	0.065845	0.001310
31-Jan-12	31	399	4127.226	413.6774	9.110025	0.100231	0.001109
29-Feb-12	29	428	4071.931	509.5172	11.12131	0.125129	0.000859
31-Mar-12	31	459	3560.097	365.5806	9.312549	0.102688	
30-Apr-12	30	489	3200.767	438.6333	12.05235	0.13704	0.001145
31-May-12	31	520	2319.806	435.9355	15.81917	0.187919	0.001641
30-Jun-12	30	550	2157.033	336.2667	13.48681	0.155893	
31-Jul-12	31	581	3310.742	646.7097	16.34157	0.195337	0.001272
31-Aug-12	31	612	3052.935	679.871	18.2134	0.222694	0.000882
30-Sep-12	30	642	2825.133	747	20.91187	0.264412	0.001391
31-Oct-12	31	673	3116.29	982.5161	23.97079	0.315284	0.001641
30-Nov-12	30	703	3031.767	1168.067	27.81221	0.385276	0.002333
31-Dec-12	31	734	3121.419	1132.774	26.62724	0.362904	
31-Jan-13	31	765	2989.226	1167.548	28.08785	0.390586	0.000893
28-Feb-13	28	793	2868.393	1360.75	32.17555	0.474395	0.002993
30-Mar-13	30	823	2290.033	1354.9	37.17215	0.591651	0.003909
30-Apr-13	30	853	2411.8	1502.733	38.38857	0.623075	0.001047
31-May-13	31	884	2085.871	1461.806	41.2046	0.700813	0.002508
30-Jun-13	30	914	2096.433	1498	41.67555	0.714547	0.000458
31-Jul-13	31	945	1975.516	1755.871	47.05679	0.888816	0.005622
31-Aug-13	31	976	1913	1753.097	47.81916	0.916412	0.000890
30-Sep-13	30	1006	1553.233	1500.167	49.13102	0.965835	0.001647
31-Oct-13	31	1037	1070.452	1171.935	52.26285	1.094805	0.004160
30-Nov-13	30	1067	0	0	0	0	
31-Dec-13	31	1098	1607.032	898.4194	35.85858	0.559055	0.018034
31-Jan-14	31	1129	948.7097	763.5484	44.59307	0.804828	0.007928
28-Feb-14	28	1157	118.7857	76.10714	39.05076	0.64071	

Table 4.4: production data and computation of WOR and WOR' - well (4)

DATE	Time Days	Cum Days	Qo stb/d	Qw stb/d	WC %	WOR	WOR'
31-Dec-10	4	4	1	0	0	0	0
31-Jan-11	31	34	751.6129	0	0	0	0.000000
28-Feb-11	28	62	2375.571	13.39286	0.560614	0.005638	0.000201
31-Mar-11	31	93	299.6774	0	0	0	
30-Apr-11	30	123	630	0	0	0	0.000000
31-May-11	31	154	2928.774	1.129032	0.038535	0.000385	0.000012
30-Jun-11	30	184	3666.667	0.966667	0.026357	0.000264	
31-Jul-11	31	215	4311.968	37.87097	0.870629	0.008783	0.000275
31-Aug-11	31	246	4039.645	115.8065	2.786856	0.028667	0.000641
30-Sep-11	30	276	2901.1	435.6	13.05481	0.15015	0.004049
31-Oct-11	31	307	4537.742	699.0968	13.3496	0.154063	0.000126
30-Nov-11	30	337	4799.567	811.1	14.45639	0.168994	0.000498
31-Dec-11	31	368	4402.29	911.3226	17.15071	0.207011	0.001226
31-Jan-12	31	399	3399.581	1314.387	27.88282	0.386632	0.005794
29-Feb-12	29	428	2965.414	1521.897	33.91556	0.513216	0.004365
31-Mar-12	31	459	2733.484	1582.065	36.65964	0.578772	0.002115
30-Apr-12	30	489	2744.533	1852.033	40.29167	0.674808	0.003201
31-May-12	31	520	1912.323	2228.774	53.82087	1.16548	0.015828
30-Jun-12	30	550	1370.267	1821.5	57.06871	1.329303	0.005461
31-Jul-12	31	581	1486.613	1436.968	49.15095	0.966605	
31-Aug-12	31	612	1839.419	1906.935	50.90109	1.036705	0.002261
30-Sep-12	30	642	2010.167	1897.8	48.56234	0.944101	
31-Oct-12	31	673	1948.323	2179.613	52.80153	1.118713	0.005633
30-Nov-12	30	703	2124.867	2218.767	51.08089	1.044191	
31-Dec-12	31	734	2091.968	2261.194	51.94371	1.080893	0.001184
31-Jan-13	31	765	2040.032	2313.774	53.14371	1.134185	0.001719
28-Feb-13	28	793	1984.107	2413.214	54.87919	1.216272	0.002932
30-Mar-13	30	823	1751.833	2014.767	53.49033	1.15009	
30-Apr-13	30	854	1950.533	2273.333	53.82114	1.165493	0.000513
31-May-13	31	885	1862.452	2541.613	57.71062	1.36466	0.006425
30-Jun-13	30	915	1790.9	2559.333	58.83209	1.429077	0.002147
31-Jul-13	31	946	1654.226	2288.774	58.04652	1.383592	
31-Aug-13	31	977	1517.71	2290.323	60.14452	1.509065	0.004048
30-Sep-13	30	1007	1232.267	2205.7	64.15711	1.789953	0.009363
31-Oct-13	31	1038	1658.032	2254.161	57.61886	1.35954	
30-Nov-13	30	1068	1556.733	2016.467	56.43308	1.295319	
31-Dec-13	31	1099	908.0645	3156.613	77.65962	3.476199	0.070351
31-Jan-14	31	1130	1122.032	2325.097	67.45024	2.072219	
28-Feb-14	28	1158	1104.107	2738.357	71.26565	2.480155	0.014569
31-Mar-14	31	1189	1243.098	2460.45	66.43494	1.979289	

Table 4.5: production data and computation of WOR and WOR' - well (5)

DATE	Time Days	Cum Days	Qo stb/d	Qw stb/d	WC %	WOR	WOR'
31-Jan-11	5	5	2672.976	7.024	0.26209	0.002628	0.00000
28-Feb-11	28	33	3055.23	12.27	0.4	0.004016	0.00005
31-Mar-11	31	64	2618.769	10.51714	0.4	0.004016	
30-Apr-11	30	94	1828.113	33.55333	1.802328	0.018354	0.00048
31-May-11	31	125	1298.975	132.9932	9.287446	0.102383	0.00271
30-Jun-11	30	155	444.2556	28.14444	5.957757	0.063352	
31-Jul-11	31	186	0	0	0	0	
31-Aug-11	31	217	0	0	0	0	0.00000
30-Sep-11	30	247	948.7333	44.6	4.489933	0.04701	0.00157
31-Oct-11	31	278	1205.543	276.469	18.65497	0.229331	0.00588
30-Nov-11	30	308	919.5195	456.7139	33.18579	0.496688	0.00891
31-Dec-11	31	339	0	0	0	0	
31-Jan-12	31	370	11.12903	0	0	0	0.00000
29-Feb-12	29	399	0	0	0	0	0.00000
31-Mar-12	31	430	16.98065	4.245161	20	0.25	0.00806
30-Apr-12	30	460	0	0	0	0	
31-May-12	31	491	279.8097	771.7452	73.39086	2.758107	0.08897
30-Jun-12	30	521	647.5267	1403.91	68.43545	2.168111	
31-Jul-12	31	552	986.1161	2182.323	68.87691	2.213048	0.00145
31-Aug-12	31	583	759.6129	1481.935	66.11213	1.950909	
30-Sep-12	30	613	498.8333	1119.203	69.17046	2.243642	0.00976
31-Oct-12	31	644	891.0742	2436.803	73.22395	2.734681	0.01584
30-Nov-12	30	674	799.4467	2660.613	76.89501	3.328069	0.01978
31-Dec-12	31	705	875.4774	2766.329	75.96035	3.159795	
31-Jan-13	31	736	665.6774	2981.484	81.74807	4.478872	0.04255
28-Feb-13	28	764	654.4821	2701.089	80.49566	4.127063	
30-Mar-13	30	794	648.7	2583.733	79.93153	3.98294	
30-Apr-13	30	825	857.82	3008.18	77.81117	3.506773	
31-May-13	31	856	503.4065	1583.921	75.88272	3.146405	
30-Jun-13	30	886	0	0	0	0	
31-Jul-13	31	917	0	0	0	0	0.00000
31-Aug-13	31	948	0	0	0	0	0.00000
30-Sep-13	30	978	0	0	0	0	0.00000
31-Oct-13	31	1009	0	0	0	0	0.00000
30-Nov-13	30	1039	0	0	0	0	0.00000

Table 4.6: production data and computation of WOR and WOR' - well (6)

DATE	Time Days	Cum Days	Qo stb/d	Qw stb/d	WC %	WOR	WOR'
31-Jul-10	1	1	761	0	0	0	0
31-Aug-10	31	32	825.0968	0	0	0	0
30-Sep-10	30	62	673.7333	0	0	0	0
31-Oct-10	31	93	756.9677	0	0	0	0
30-Nov-10	30	123	818.9	0	0	0	0
31-Dec-10	31	154	802.6452	0	0	0	0
31-Jan-11	31	185	669.2258	0	0	0	0
28-Feb-11	28	213	679.8571	39.75	5.523847	0.058468	0.002088
31-Mar-11	31	244	587.7742	0.580645	0.09869	0.000988	
30-Apr-11	30	274	2451.667	90	3.540984	0.03671	0.001191
31-May-11	31	305	3596.129	449.6452	11.11395	0.125036	0.002849
30-Jun-11	30	335	2932.7	496.3	14.47361	0.16923	0.001473
31-Jul-11	31	366	2896.839	279.5806	8.801755	0.096512	
31-Aug-11	31	397	2367.355	591.8387	20	0.25	0.004951
30-Sep-11	30	427	1686	379.8667	18.38776	0.225306	
31-Oct-11	31	458	1803.613	546.2581	23.2463	0.302869	0.002502
30-Nov-11	30	488	1653.433	789.1	32.30662	0.477249	0.005813
31-Dec-11	31	519	1421.484	766.1935	35.02315	0.53901	0.001992
31-Jan-12	31	550	1407.258	799.4194	36.22729	0.568069	0.000937
29-Feb-12	29	579	1573.379	900.6207	36.40342	0.572412	0.00015
31-Mar-12	31	610	1569.581	1519.419	49.18807	0.968042	0.012762
30-Apr-12	30	640	1204.233	1750.833	59.24852	1.453899	0.016195
31-May-12	31	671	1297.581	1552.935	54.4791	1.196793	
30-Jun-12	30	701	1483.9	1535.067	50.84742	1.034481	
31-Jul-12	31	732	1662.484	1424.258	46.14114	0.856705	
31-Aug-12	31	763	1365.226	1537.645	52.96981	1.126294	0.008696
30-Sep-12	30	793	1278.967	1624.867	55.95592	1.270453	0.004805
31-Oct-12	31	824	1425.452	1740.742	54.97901	1.221186	
30-Nov-12	30	854	1423.8	1497.333	51.25864	1.051646	
31-Dec-12	31	885	1268.839	1708.613	57.38508	1.346596	0.009515
31-Jan-13	31	916	1235.645	1562.258	55.83674	1.264326	
28-Feb-13	28	944	1273.536	1543.036	54.78419	1.211616	
30-Mar-13	30	974	1091.7	1123.067	50.70813	1.028732	
30-Apr-13	30	1004	1637.233	1278.9	43.85602	0.781135	
31-May-13	31	1035	2022.452	1621.29	44.4952	0.801646	0.000662
30-Jun-13	30	1065	2031.567	1664.233	45.03039	0.819187	0.000585
31-Jul-13	31	1096	1605.839	1706.29	51.51642	1.062554	0.007851
31-Aug-13	31	1127	1475.516	1638.806	52.6216	1.110667	0.001552
30-Sep-13	30	1157	1332.367	1254.667	48.49828	0.941683	
31-Oct-13	31	1188	1298.935	1293.065	49.88675	0.99548	0.001735

Table 4.7: production data and computation of WOR and WOR' - well (7)

DATE	Time Days	Cum Days	Qo stb/d	Qw stb/d	WC %	WOR	WOR'
31-Jul-10	4	4	292.25	0	0	0	0.00000
31-Aug-10	31	35	996.7097	0	0	0	0.00000
30-Sep-10	30	65	10321	0	0	0	0.00000
31-Oct-10	31	96	4157.29	0	0	0	0.00000
30-Nov-10	30	126	0	0	0	0	0.00000
31-Dec-10	31	157	5958.161	0	0	0	0.00000
31-Jan-11	31	188	9846.871	0	0	0	0.00000
28-Feb-11	28	216	3382.429	41.03571	1.198661	0.012132	0.00043
31-Mar-11	31	247	2252.452	0	0	0	
30-Apr-11	30	277	6197.433	7.566667	0.121945	0.001221	0.00004
31-May-11	31	308	3982.419	1	0.025104	0.000251	
30-Jun-11	30	338	154.9667	2.9	1.836993	0.018714	0.00062
31-Jul-11	31	369	10011.13	152.5161	1.500605	0.015235	
31-Aug-11	31	400	9905.032	412.7097	4	0.041667	0.00085
30-Sep-11	30	430	7673.167	443.5667	5.464842	0.057808	0.00054
31-Oct-11	31	461	5068.645	1178.484	18.86441	0.232505	0.00564
30-Nov-11	30	491	4260.8	1251.1	22.69816	0.29363	0.00204
31-Dec-11	31	522	2383.032	1087.516	31.33557	0.456358	0.00525
31-Jan-12	31	553	2128.839	1047.097	32.96971	0.491863	0.00115
29-Feb-12	29	582	1396.034	0	0	0	
28-Mar-12	28	610	0	0	0	0	0.00000
22-Sep-12	22	788	986.4545	87.09091	8.112457	0.088287	0.00401
31-Oct-12	31	827	849.5806	13.48387	1.562325	0.015871	
30-Nov-12	30	857	51.73333	1.6	3	0.030928	0.00050
31-Dec-12	31	888	0	0	0	0	
31-Jan-13	31	919	0	0	0	0	0.00000
28-Feb-13	28	947	0	0	0	0	0.00000
30-Mar-13	30	977	3988.967	95.96667	2.349284	0.024058	0.00080
30-Apr-13	30	1008	2582.967	203.7667	7.312026	0.078889	0.00183
31-May-13	31	1039	8737.065	2211.452	20.19864	0.253112	0.00562
30-Jun-13	30	1069	7232.133	2550.4	26.07096	0.352648	0.00332
31-Jul-13	31	1100	5838.645	3422.903	36.95822	0.58625	0.00754
31-Aug-13	31	1131	5462.161	3431	38.58021	0.62814	0.00135
30-Sep-13	30	1161	4031.8	3102.7	43.48868	0.769557	0.00471
31-Oct-13	31	1192	4719.935	4157.871	46.83444	0.880917	0.00359
30-Nov-13	30	1222	4898.833	4842.833	49.71257	0.988569	0.00359
31-Dec-13	31	1253	4926	5896	54.48161	1.196914	0.00672
31-Jan-14	31	1284	5144.258	6411.645	55.48372	1.246369	0.00160
28-Feb-14	28	1312	5372.036	7091.643	56.89847	1.320103	0.00263

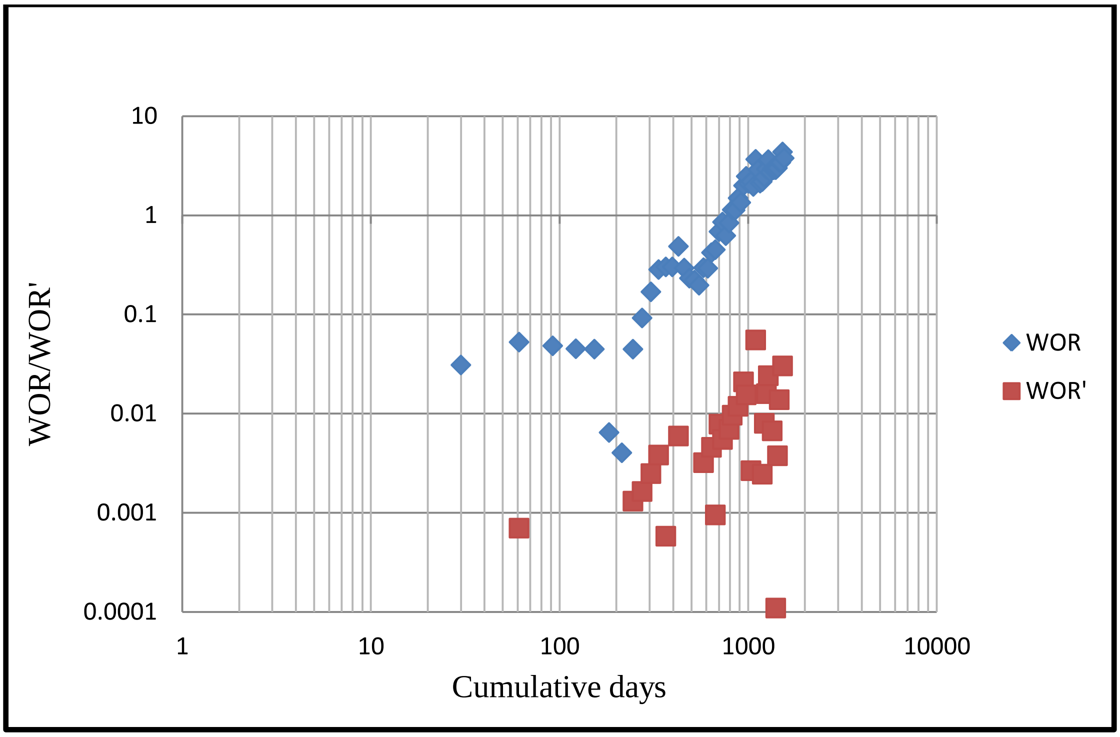

Figure 4.1: WOR and WOR' derivatives plot for well (1)

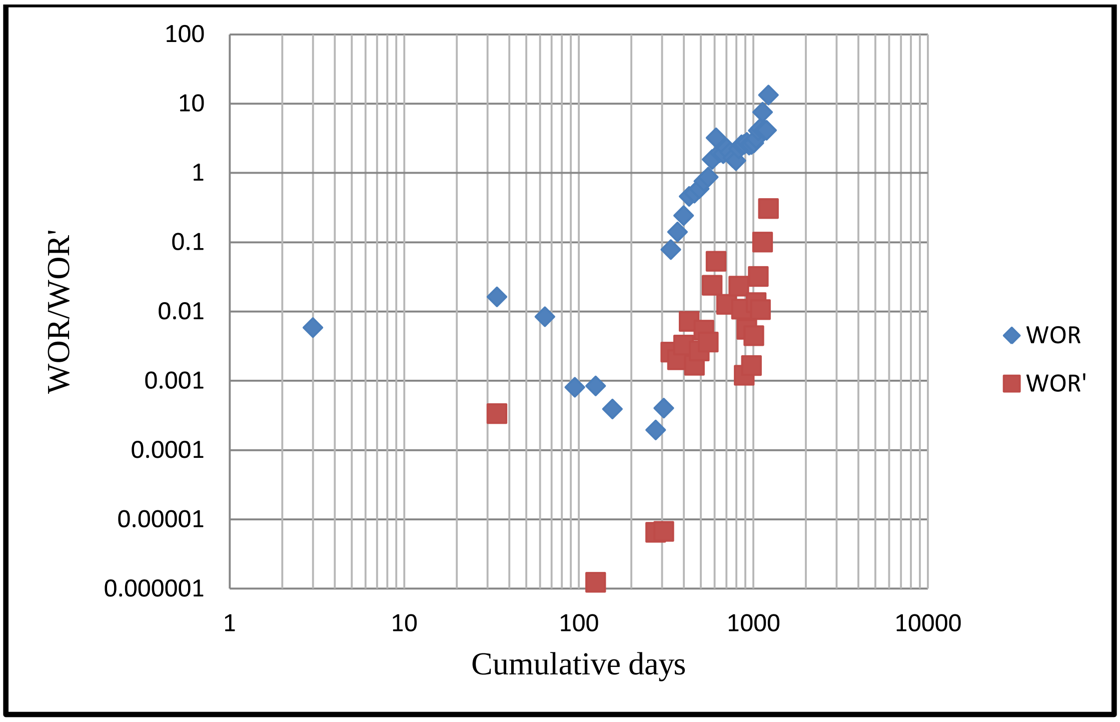

Figure 4.2: WOR and WOR' derivatives plot for well (2)

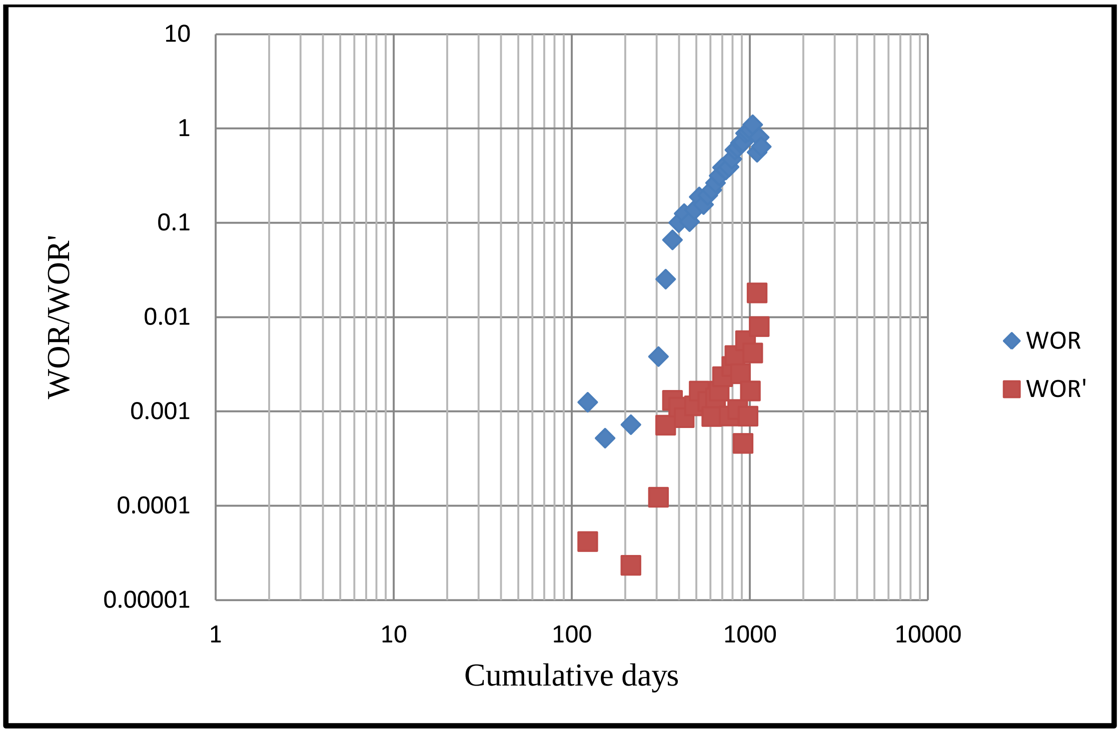

Figure 4.3: WOR and WOR' derivatives plot for well (3)

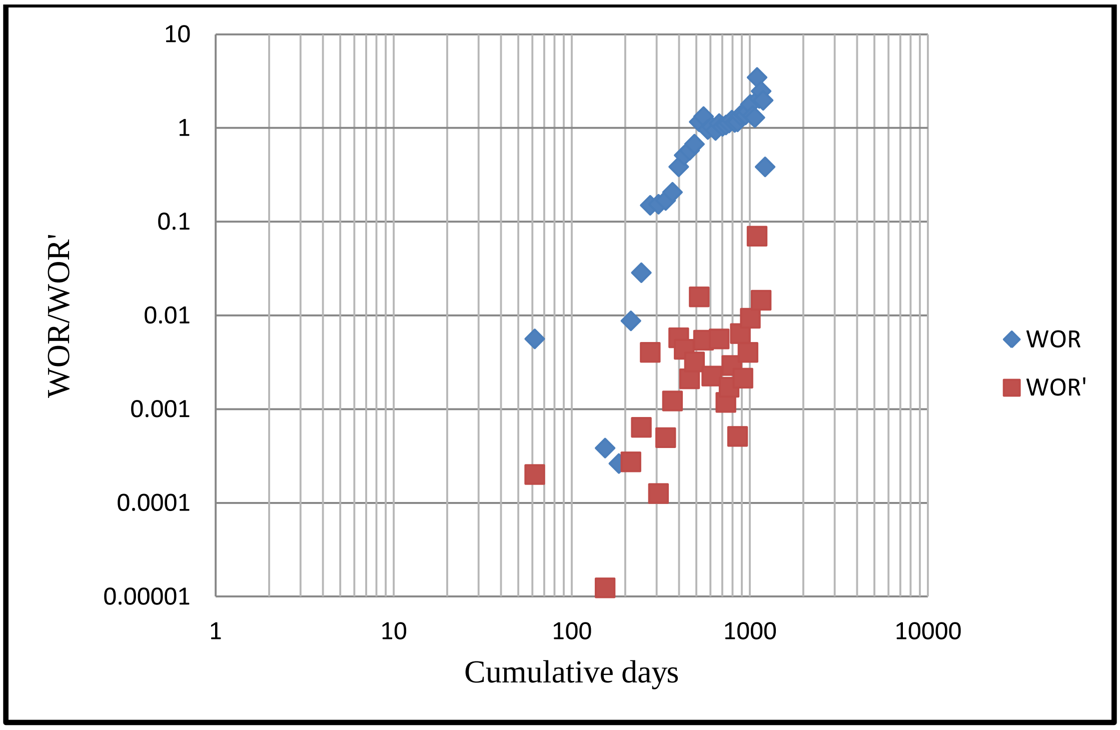

Figure 4.4: WOR and WOR' derivatives plot for well (4)

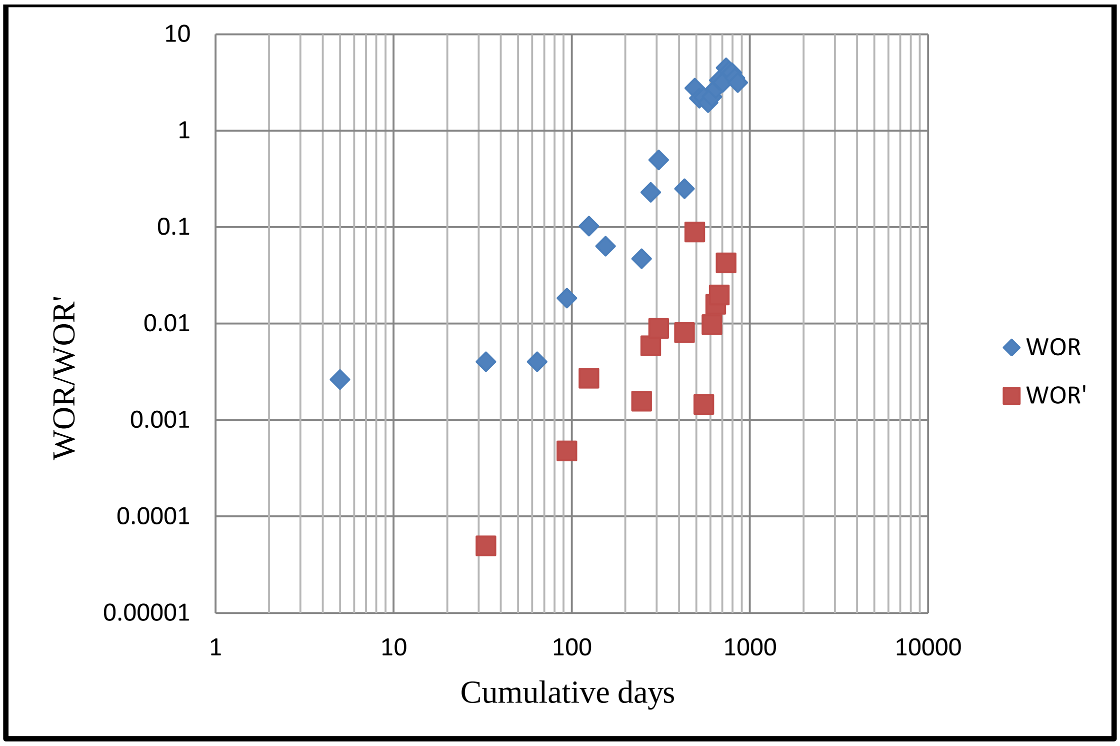

Figure 4.5: WOR and WOR' derivatives plot for well (5)

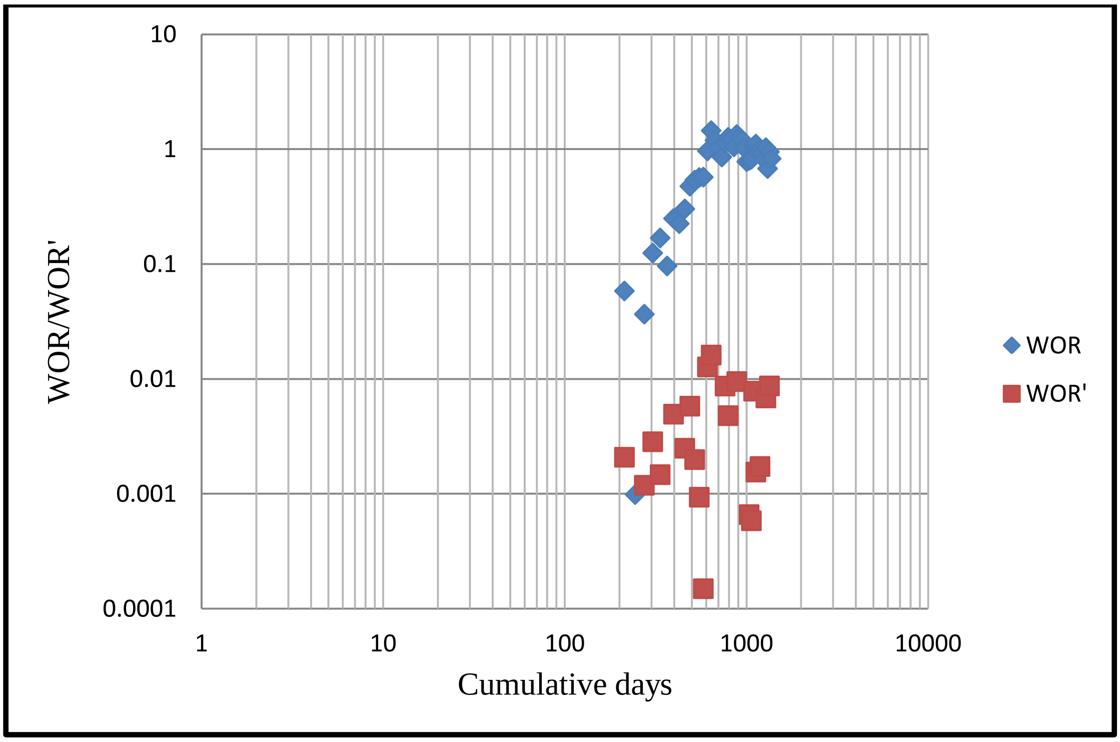

Figure 4.6: WOR and WOR' derivatives plot for well (6)

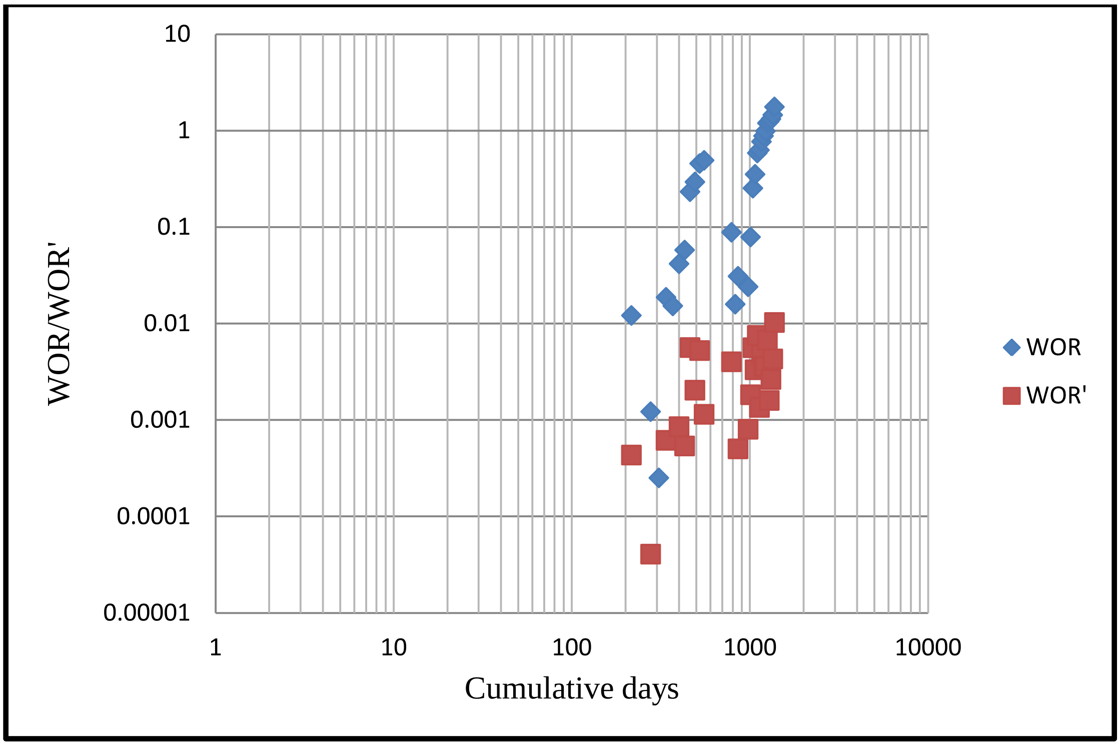

Figure 4.7: WOR and WOR' derivatives plot for well (7)

Chapter 5

Conclusion and Recommendations

5.1. Summary of the work:

Excess water production not only negatively affects the oil production rate, but also entails costly and time-consuming water management operations from remedial actions in oil well and oil field to the environmental considerations for waste water disposal.

The five wells located in sandstone reservoir with high vertical and horizontal permeability and high water saturation of the formation well set the channeling phenomenon as the main reason of watery wells. The others introduced normal with high watercut.

In order to be able to deal with the excess water production problem effectively, it is very important to identify the source of the problem first.

This study applies a methodology which can be used to quickly diagnose and evaluate water production mechanisms, so the derivative method has a number of advantages:

1. It mainly uses available production history data for detecting water problems.
2. It can be used to rapidly screen a great number of wells.
3. It entails the best reservoir engineering principles and practices.
4. There should be more production and reservoir engineering opportunities and benefits by using this diagnostic technique as one further progresses along this approach.

Using Microsoft Excel format program on calculating and plotting the derivative response was easy, simple and didn't take long time. The results of application were compared with the standard of Chan's plots to make a good decision.

The change in slope of WOR and WOR derivative and the value of WOR derivative are good indicators for differentiation of normal displacement and production behavior.

5.2. The recommendations:

From the outcomes of research, the recommendations can be:

1. Choosing the optimum solution for the specified problem to reduce or prevent excess water production.
2. Close monitoring using logs and well test will improve the understanding of reservoir flow behavior and identify excessive water production mechanisms during the life of the well.
3. The WOR diagnostic plots can easily misunderstand and therefore should not be considered alone to achieve high accurately results on diagnosis the specific cause of a water production problem.
4. According to point number (3), one of the objectives of this research was trying to use another method for verifications from the results of derivative method, that method was spectral analysis which prepared by Egbe and Dulu (2005). But because of lack of information and short time, our study stopped at the middle of the project.

   If there are sufficient information about spectral analysis method and enough time, there will be good results.

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