INTEGRATED OF ROCK TYPING AND GEOMECHANICS STUDIES FOR FIELD DEVELOPMENT PLAN OPTIMIZATION

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ABSTRACT

Once a field has been identified, and a general method of reservoir exploitation decided, there are several methods to achieve the reservoir management goal, but some ways may cost twice as much as others. The most critical operations to developing a field are drilling of wells, and it overemphasizes which in the early stages of field development. This study will cover challenges related to field development in the presence of a geological complication. In the Arabic Gulf area, most of the reservoirs are carbonate is distinguished by complex textural heterogeneity that corresponds to extreme permeability varieties which are the controlling factor in reservoir production. The uncertainty of information in the reservoir and rock mechanics properties have proven to be extremely challenging that faced oil and gas companies during the Appraisal and development phase. Numerous lost-time incidents including stuck pipe, pack – off, lost circulation and difficulties in running casing were experienced during drilling new wells. Moreover, Due to the significant differences between log-derived water saturation and capillary pressure model-derived water saturation profiles during the dynamic model, the lake of the original hydrocarbon amount will raise the associated risks and uncertainties of the model. That becomes necessary to perform the task of integrated reservoir characterization and geomechanics in order to find optimum field development plan, that is the objective of this study was to characterized reservoir rock by distributing petrophysical rock types, porosity, and permeability and applied rock typing among the transition zone to increase the certainty of oil in place. Moreover, design a new modify for mud window to mitigate drilling hazard was one of the primary outcomes in this study. The objective of this study applied in a case study in the Arabic Gulf area. Several approaches were performed to determine which method was more reliable for our case study to identification rock typing, FZI*showed a better result than other methods, it has created three petrophysical rock types, which depend on specific porosity and permeability trends. The distribution of petrophysical rock type, porosity, and permeability perform in the form of the 3D model by using geostatic model. In the geomechanical evaluation, there was a notable difference in geomechanical characteristics. The values for these properties rise at deeper depths, most possibly because of the degree of the overburden and increased compaction, as shown in the increasing sonic speeds. A result from integrated rock typing and geomechanics showed that PRT 3 identified as a best reservoir and highest lost circulation zone, according to a highly porosity and permeability values that varies from 0.17 to 0.25 and from 237 to 349 MD respectively .Integrated FZI* as an indicator of loss circulation zone that showed probability of mud loss increased with increased FZI* values, with median line principle guide us to design a new approach for optimum mud window design to reduce L.C and tight hole problem. The outcomes of this research can be utilized in the field industry to improved reservoir characterized and mitigate drilling problem by applying our new modify for mud window design.

ABSTRAK

Sebaik sahaja bidang telah dikenalpasti, dan kaedah umum eksploitasi reservoir diputuskan, terdapat beberapa kaedah untuk mencapai matlamat pengurusan reservoir, tetapi beberapa cara mungkin dikenakan biaya dua kali ganda berbanding yang lain. Operasi paling kritikal untuk membangunkan bidang adalah penggerudian telaga, dan ia terlalu mengagumkan yang pada tahap awal pembangunan lapangan. Kajian ini akan merangkumi cabaran yang berkaitan dengan pembangunan lapangan di hadapan komplikasi geologi. Di kawasan Teluk Arab, kebanyakan takungan adalah karbonat dibezakan oleh heterogeneity tekstural yang kompleks yang sepadan dengan jenis kebolehtelapan yang melampau yang merupakan faktor pengawalan dalam pengeluaran reservoir. Ketidakpastian maklumat dalam sifat reserbor dan mekanik batu telah terbukti sangat mencabar yang dihadapi oleh syarikat minyak dan gas semasa fasa Penilaian dan pembangunan. Banyak insiden yang hilang termasuk paip yang terperangkap, pembungkusan, kehilangan peredaran dan kesukaran dalam mengangkut selongsong telah berpengalaman semasa pengeboran sumur baru. Selain itu, disebabkan oleh perbezaan ketara antara profil ketepuan air dan tekanan kapilari yang diperoleh daripada model ketepuan air yang dihasilkan oleh model semasa dinamik, tasik jumlah H.C yang asal akan meningkatkan risiko dan ketidakpastian model. Yang menjadi perlu untuk melaksanakan tugas pencirian takungan terintegrasi dan geomekanik untuk mencari pelan pembangunan lapangan yang optimum, objektif kajian ini adalah mencirikan batuan reservoir dengan mengedarkan jenis batu petrofizik, keliangan, dan kebolehtelapan dan menaip batu menaip di antara zon peralihan untuk meningkatkan kepastian HC di tempat. Lebih-lebih lagi, reka bentuk yang baru diubahsuai untuk tingkap lumpur untuk mengurangkan bahaya penggerudian adalah salah satu hasil utama dalam kajian ini. Objektif kajian ini digunakan dalam kajian kes di kawasan Teluk Arab. Beberapa pendekatan telah dilakukan untuk menentukan kaedah mana yang lebih dipercayai untuk kajian kes kami untuk pengenalpastian batu menaip, FZI * menunjukkan hasil yang lebih baik daripada kaedah lain, ia telah mencipta tiga jenis petrophysical rock, yang bergantung kepada keliangan tertentu dan trend kebolehtelapan. Pengagihan jenis batu petrofizik, keliangan, dan kebolehtelapan dilakukan dalam bentuk model 3D dengan menggunakan model geostatik. Dalam penilaian geomekanikal, terdapat perbezaan yang ketara dalam ciri-ciri geomekanikal. Nilai-nilai untuk sifat-sifat ini meningkat pada kedalaman yang lebih mendalam, paling mungkin kerana tahap overburden dan peningkatan pemadatan, seperti yang ditunjukkan dalam peningkatan kelajuan sonik. Hasil daripada penekanan batu bersepadu dan geomekanik menunjukkan bahawa PRT 3 dikenalpasti sebagai takungan terbaik dan zon peredaran kehilangan tertinggi, menurut nilai porositas dan kebolehtelapan yang berbeza-beza antara 0.17 hingga 0.25 dan dari 237 kepada 349 MD masing-masing.Integrated FZI * sebagai penunjuk zon peredaran kerugian yang menunjukkan kebarangkalian kehilangan lumpur bertambah dengan nilai FZI * yang meningkat, dengan prinsip garis median membimbing kita untuk merancang pendekatan baru untuk reka bentuk tetingkap lumpur optimum untuk mengurangkan L.C dan masalah lubang yang ketat. Hasil penyelidikan ini boleh digunakan dalam industri lapangan untuk meningkatkan reserbor yang dicirikan dan mengurangkan masalah penggerudian dengan menggunakan modifikasi baru kami untuk reka bentuk tingkap lumpur.

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LIST OF ABBREVIATIONS

FDPs	-	Field development plans
NPT	-	Nonproductive time
DRT	-	Distinct rock type
LF	-	Lithofacies
GDE	-	Gross deposition environment
EOD	-	Deposition map environment
SCAL	-	Special core analysis
PSRT	-	Petrophysical Static Rock typing
PDRT	-	Petrophysical Dynamic Rock typing
HFU	-	Hydraulic flow units
FWL	-	Free water level
FZI	-	Flow zone indicator
DRT	-	Discrete rock type
FBP	-	Fracture breakdown pressure
RQI_{IG}	-	Modified RQI give by Izadi and Ghalambor
RQI	-	Reservoir quality index
UCS	-	Unconfined Compressive Strength
FANG	-	Friction Angle
YME_STAT	-	Static Young's modulus
PR_STAT	-	Poisson's ratio
NXRD	-	Normalized resistivity
NXRHO	-	Normalized density log
NXGR	-	Normalized gamma ray log
NXSP	-	Normalized spontaneous potential log
NXDT	-	Normalized sonic log
NXNPH	-	Normalized neutron porosity log
RCAL	-	Routine core analysis

LIST OF SYMBOLS

D	-	Diameter
rmh	-	efficient or mean radius
ʈ	-	tortuosity
$\mathcal{V}$	-	Velocity
Fs	-	shape factor
Sv	-	vertical stress
$SHmax$	-	Maximum horizontal stress
$Shmin$	-	Minimum Principal horizontal stress
Pp	-	pore pressure
C_O	-	uncconfined compressive strength
E	-	Young's modulus
K	-	bulk modulus
Vclay	-	fractional volume of clay minerals
G_{dyn}	-	Dynamic Shear Modulus
K_{dyn}	-	Dynamic Bulk Modulus
E_{dyn}	-	Dynamic Young's Modulus
v_{dyn}	-	Dynamic Poisson's Ratio
$\emptyset_Z$	-	Normalize effective porosity
k	-	Permeability
ρ_b	-	Bulk Density
Δt_{shear}	-	Shear Slowness
Δt_{comp}	-	compressional Slowness
$\sigma\Delta T$	-	thermoelastic effect

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CHAPTER 1

INTRODUCTION

1.1 Background study

It is commonly known that exploration and production' lifecycle' entered five steps. These steps move for the way oil and gas are found to what appears once the hydrocarbon field has been decommissioned. Hazards at each stage and uncertainty info concerning the field cost the firm tens of hundred million greenbacks, that should be handled responsibly by oil and gas corporations.

After confirming the field has a quantity of hydrocarbon during the exploration stage, the appraisal stage start. The principal aim of that step is to develop the certainty or probability of the volume of the hydrocarbon field and its characteristics. While this stage beginning, exploration well and other wells are drilling to gathering numerous data and samples from the reservoir, another seismic survey is returned to get a better image of the reservoir. Those activities need a long while and gain tens to hundreds of billions of dollars. Further wells and geological analysis help petroleum geologists, geophysicists and field engineers grasp the reservoir better. For example, they attempt to determine if the rock or fluid properties vary from the discovery well, how much oil or gas would be in the reservoir, and how quickly oil or gas can flow through the reservoir. All of this information will decide the structure and level of the Problem History development plan.

Field development plans (FDPs) grant you the best technical clarifications for field optimization. FDPs includes all activities and processes required to develop a field to increase the production and minimize the sufficient charge: environmental impact, geophysics, geology, reservoir and production engineering, infrastructure, well design and construction, completion design, surface facilities, economics and risk evaluation.

In general, once a field has been discovered, and a usual method of reservoir exploitation picked, there are many ways to achieve the reservoir management goal, but some ways may cost twice as much as others. The most critical operations to developing a field are drilling of wells is overemphasized in the early stages of field development (Bennett,1981). The tendency is to drill in relatively safe locations to mitigate all the drilling problem such wellbore instability, and to complete wells in the most prolific zones only, to enhance early production it is essential to offer the best reservoir characteristic. Early planning is strongly recommended to maximize ultimate recovery and minimize future operating problems; for example, to maximize easy life and to reduce costs of future work-overs and conversion to artificial lift (Bennett,1981).

Years of hydrocarbon exploration and production brings field development operation and reservoir characterization with several challenges coming from severely depleted reservoirs. During development stage oil companies starting to drill new wells to increase the production to achieve the plateau phase "maximum field capacity", routine operation of oil and gas companies in predicting high fluid loss zone and mismatching between field activities are designed to develop the field and understood the geology and tectonics cause increase in the drilling problem that consumes companies a huge of money as a result of an increase in the nonproductive time (NPT). Moreover, using the traditional idea to distribute the properties (porosity, permeability) base on Petro-physical group "static rock typing "usually come with under evaluate properties and reserve in the reservoir in this situation. It is required to apply new techniques to find the most reliable description for the reservoir and drill a new well in depleted zones with minimal cost during these stages.

Putting the best plan for development field require and to mitigate most of the drilling problem, and challenges need to know the reservoir, the better placed to optimize its lifetime performance. Comprehend reservoir rocks and fluids through accurate analyses and characterization guide to minimize the problem and cost during the appraisal and develop stage in oil and gas life. Moreover, understanding of vertical spread of depositional rock types "are defined inside the context of the large-scale geologic formation and characterize these authentic rock properties at deposition and

earlier than extensive post-depositional diagenesis has occurred "helps to determine the depositional environment which then drives to a classification of the reservoir geometry and flow properties "Petro-facies, static rock types or petrophysical rock types that is defined as are layers of rock including similar petrophysical correlation and average porosity and permeability containers in the fields" (Rushing,2008). Then it will guide to define the reservoir rock typing or hydraulic rock typing "is a method of up-scaling petrophysical knowledge to produce more accurate input for 3D geological and flow simulation models" (Turkey et al.,2012).

Integrated reservoir characterization needs the acquisition and interpretation of static data such as reservoir structure and dynamic data such as product performance. The objective of this study proves that reservoir rock typing and geomechanics are the best and essential integrated approach of improving the knowledge of the reservoir to optimization field development plan and minimize the cost of drilling by improving the real-time drilling and mitigate the drilling problem.

1.2 Problem Statement

Operation during the appraisal and development stages are recognized the most expensive, dangerous, and complicated operations in the oil and gas industry, which generally consumes enormous amounts of CAPEX and OPEX. There are several technical and operational challenges introducing more nonproductive times (NPT) and extra costs. In the Arabic Gulf area, most of the reservoirs are carbonate is distinguished by complex textural heterogeneity that corresponds to extreme permeability varieties which are the controlling factor in reservoir production (Turkey et al., 2012).

Prior research generally confirms that the original H.C in a place describes the asset quantity of companies that are needed to determine at a high accuracy level with tiniest uncertainties to avoid any likely hazards with the field development plan. CAPEX and OPEX are affected directly by the percentage of certainty of the reserves that can be produced (Faisal al-Jenaibi et al., 2008).

This study will cover challenges related to field development in the presence of a geological complication. The uncertainty of information in the reservoir and rock mechanics properties have proven to be extremely challenging that faced oil and gas companies during the Appraisal and development phase. Numerous lost-time incidents including stuck pipe, pack – off, lost circulation and difficulties in running casing were experienced during drilling new wells.

The lake of the original H.C amount will raise the associated risks and uncertainties of the model and will also introduce additional challengers into the background of matching behaviours. Due to the significant differences between log-derived water saturation and capillary pressure model-derived water saturation profiles during the dynamic model initialization step, further time-loss was expended in the observation data.

1.3 Research Objectives

This research applies several methods to investigate the following objective:

(a) To screen and characterize the best method for optimization field development plan.

(b) To Identify the most reliable rock typing technique to classify rocks-based porosity, permeability and pore size distribution and introduce a better characterization of oil and gas column thickness, top of the transition zone and capillary pressure curve.

(c) To improve drilling optimizations strategy and reduce nonproductive time by using geomechanics aspect and rock typing.

1.4 Scope

The scope of this research is sketched on the objective stated above. They are as follows:

- Delving into challenges that modify to achieve maximum efficiency for the field development plan.

- Using rock typing methods as an essential and accurate approach to solves the field development plan application to cut down the suspicions in the permeability, water saturation estimates and distribute the properties in the reservoir by using evaluation of log, routine core and special core analysis.

- Wading into the new approach of predicting the capillary as a new way to improve the result out from rock typing in describing the reservoir properties, increase the certainties of H.C in place, and determine the better placement for drill new well.

- Providing wellbore stability, pore pressure and fracture gradient analyses for the drilling program by generation geomechanical modal by using the information from offset wells, well logs.

1.5 Hypothesis

Oil and gas companies that experience more information about reservoir "rock and fluid properties "will get better characteristics for the reservoir and the best strategy for field development and future drilling operation. In other words, study the impact of some parameter such (wettability, permeability, and rock mechanisms) with a proper distribution for these parameters will optimization the field development plan.

1.6 Significant

This scheme is significant because it touches a sector that is of critical importance to oil and gas industries, this study will redound to the benefit of oil and gas industry that plays an essential role in the world economy. The economic crisis makes increasing the demand for idea or project that can decrease the effective cost for drill and develop oil fields. This study will redound to improve traditional rock typing workflow that was used describing physical properties of different, in net pay calculation and describing flow unit. Also, focus on the geo-mechanical aspect that applies it with rock typing will be guided to minimize development operation challenges. Thus, companies that utilize the suggested approach obtained from the result of this research will be able to increase the certainty for the information for better reservoir characteristics and optimize field development plan with minimum cost-effective. Engineers will be guided on what should do to achieve all objective of theses study. For the researcher, the research will help them uncover significant areas in the reservoir characteristics and FDPS operation that many researchers were not able to investigate. Thus, using a new theory on reservoir characterization and FDPS may be arrived at.

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