PORE PRESSURE PREDICTION: A CASE STUDY OF BLOCK A, SABAH INBOARD & BARAM BASIN, SABAH OFFSHORE

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“My dearest husband, parents, siblings, family and friends”

This is for all of you

Thank you, Allah, for giving me a chance to be your humble servant

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ABSTRAK

Memahami ramalan tekanan pori sangat penting dalam pelbagai peringkat proses petroleum. Masalah tekanan pori semasa penggerudian seperti insiden kawalan telaga, hilang peredaran telaga dan kerosakan reservoir yang sering membawa kepada penggerudian semula telaga yang mahal, pemberhentian penggerudian telaga, letupan bawah tanah dan kehilangan nyawa pengendali penggerudian di atas pelantar. Blok A yang terletak di kawasan perairan Sabah. Beberapa telaga telah digerudi dan telah mengalami tekanan pori yang tidak dijangka yang menyebabkan pemberhentian penggerudian telaga lebih awal dari yang dicadangkan dan mengakibatkan kegagalan mencapai objektif menggerudi telaga itu. Objektif kajian ini adalah untuk menganalisis geologi serantau untuk memahami mekanisme tekanan pori berlebihan dan bilakah tekanan pori berlebihan mula terjadi. Kedua, ramalan tekanan pori menggunakan data telaga terdekat di dalam Blok A, dengan menggunakan kaedah Eaton & Bowers dan menggunakan kaedah terbaik yang telah dioptimumkan berdasarkan interpretasi geologi dan model tekanan pori secara serantau. Dan akhirnya menganggarkan panjang maksimum ruang hidrokarbon untuk potensi prospek di Blok A yang masih ada di dalam lingkungan kedalaman tekanan pori yang tinggi. Skop kajian ini akan merangkumi kajian geologi termasuk stratigrafi urutan, tafsiran seismik, tafsiran & analisis fizikal seismik, pemendapan persekitaran kasar (GDE) dan evolusi struktur Blok A. Ramalan tekanan pori menggunakan data sedia ada dan menganggarkan maksimum panjang ruang hidrokarbon untuk melihat potensi prospek yang mengandungi gas dengan pori yang tinggi. Kajian geologi serantau memberi anggaran usia permulaan tekanan pori yang tinggi dalam kawasan Blok A. Hasil ramalan tekanan pori menunjukkan bahawa kaedah Eaton mempunyai keupayaan untuk meramal lebih baik rejim tekanan pori yang tinggi berbanding dengan kaedah Bowers. Dengan menggunakan kaedah Eaton, peta magnitud tekanan pori tinggi telah dihasilkan, dan menggunakan peta magnitud tekanan pori tinggi ini, panjang

maksimum ruang hidrokarbon telah dianggarkan untuk 3 potensi prospek gas tekanan pori yang tinggi. Model tekanan pori yang telah dibina dalam kajian ini, bukan sahaja boleh digunakan untuk meramalkan panjang maksimum ruang hidrokarbon untuk potensi baki prospek gas yang mempunyai tekanan tinggi, ini juga dapat memberi manfaat kepada pengiraan panjang maksimum ruang hidrokarbon untuk sebarang kemungkinan prospek lain yang berpotensi dan ia juga dapat digunakan untuk ramalan tekanan pori pada masa hadapan.

ABSTRACT

Understanding pore pressure prediction is critical in various stage of frontier in petroleum process. Pore pressure related problems during drilling such as well control incidents, lost circulation & reservoir damages which often leads to expensive sidetracks, well abandonments, underground blowout & the loss of life of the drilling operators on the rig. Block A located in Sabah Basins, a few wells have been drilled & encountered unexpected overpressure which led to early abandonments & resulting to failure on achieving well objectives. The objective of this study is to first interpreted regional geology to understand the overpressure onset and overpressure mechanisms. Secondly, predict pore pressure using available nearby wells data within Block A, by using Eaton & Bowers methods and best fit method that has been optimized based on geological interpretation and model the pore pressure regionally. And finally estimates maximum possible hydrocarbon column length model for Block A remaining potential of deep gas overpressured play. The scope of this study will include geological study including sequence stratigraphy, seismic interpretation, seismic facies interpretation & analysis, gross depositional environment (GDE) & structural evolution of Block A. The pore pressure prediction using available well data and estimating maximum possible hydrocarbon column length for remaining potential of deep gas overpressured play. The regional geological studies result gave the estimated age of overpressure onset within Block A area. The pore pressure prediction results show that Eaton method has ability to better predict the overpressure regime compared to Bowers method. Using the Eaton method, an overpressure magnitude map has been produced, and using this overpressure magnitude map, 3 potential deep overpressure gas prospects maximum hydrocarbon column length has been estimated. Pore pressure model that has been built within this study, not only can be used to predict maximum hydrocarbon column length for current remaining potential of deep gas overpressured

play, it is also can benefit future maximum hydrocarbon column length for any other potential play and it can be used for future drilling pore pressure prediction.

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LIST OF ABBREVIATIONS

DRU	- Deep Regional Unconformity
DST	- Drill-Stem Test
FIT	- Field Integrity Test
GDE	- Gross Depositional Environment
LIU	- Lower Regional Unconformity
LOT	- Leak-Off Test
MDT	- Modular Dynamic Test
NCT	- Non- Compacted Trend
PSC	- Production-Sharing Contract
RFT	- Repeat Formation Test
SRU	- Shallow Regional Unconformity
UIU	- Upper Regional Unconformity
VES	- Vertical Effective Stress
2D	- Two-Dimensional Space
3D	- Three-Dimensional Space

LIST OF SYMBOLS

A, B	-	Virgin Curve Parameters
°C	-	Degree Celcius
P	-	Pore Fluid Stress
S	-	Vertical Overburden Stress
V	-	Velocity
σ	-	Effective Stress Acting on The Rock Frame

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Understanding pore pressure is critical in various stages of frontier hydrocarbon exploration, development, exploitation & drilling. The benefits of understanding pore pressure are not only to successful exploration & development drilling, but also it is one of the most important safety elements that should be considered before drilling a well. Pore pressure related problems during drilling such as well control incidents, lost circulations & reservoir damages which often leads to expensive sidetracks, well abandonments, underground blowouts & the loss of life of the drilling operators on the rig.

Even though so many wells have been drilled over time especially within matured basin, pore pressure prediction was observed to always been wrongly predicted and was normally been underpredicted, thus, this means the understanding of pore pressure prediction over matured basin especially, has been overlooked.

To understand pore pressure of the area, geological setting of the area needs to be understood. A few elements of geological understanding, especially depositional environment, including structural elements and this, will help on overpressure onset prediction. Area definition by geological setting and the first mechanisms overpressure generation understanding will help to better predict on overpressure magnitude thus optimization of the pore pressure model can be done. The wells data of the area will also be used to determine pore pressure, using a few methods to test (Tau, Eaton & Bowers), use one of the method which best fit the pressure of Block A and will be design according to geological understanding to further optimize the pore pressure model.

There are remaining potential exploration in the deep gas overpressured play at Block A. Using optimized pore pressure model, the maximum column length prediction over remaining potential deep gas overpressured play can be better predicted. This pore pressure prediction will be done over Block A area, offshore Sabah.

1.2 Statement of Problem

Well T-1 was drilled within Block A and early abandonment needs to be done due to overpressure surprise encountered at the deeper depth, 9580 ft of AHBDF which reflects overpressure greater than 0.53 psi/ft. Well TDW-1 was drilled nearby a decade later and was abandoned 600 ftss shallower due to overpressure encountered at depth 13585 ft of AHBDF which reflects overpressure to a maximum 2895 psi above hydrostatic near TD. The example shows pre-drill evaluation failed to predict overpressure that will be encountered by the wells. These scenarios have led to early wells abandonment, hence may likely fail to achieve wells objectives. The strategy is to re-visit wells data over Block A area, understand the geological settings & mechanisms of overpressure generation and model the pore pressure for Block A.

A few remaining potential of deep gas overpressured play has been identified within Block A. In an overpressured system, there is a risk that the top seal may be breached by the high pressure, thus leads to a reduced hydrocarbon column or at worst, a completely blown trap. Optimized pore pressure modelling can be a key to a successful exploration campaign.

1.3 Objectives

The objectives of the pore pressure prediction are:

i. To interpret geology over Block A, understand the first mechanisms of overpressure generation and use these understandings with overpressure observed in wells within Block A.
ii. To predict pore pressure by using Block A wells data and come out with optimized method of prediction/model, based on geological understanding
iii. To estimate maximum possible hydrocarbon column length for Block A remaining potential of deep gas overpressured play, based on optimized method of prediction/model.

1.4 Hypothesis

The hypotheses of this study are predicted as below:

i. Overpressure onset starts at shelf edge for the outer shelf, shallow onset overpressures in the inner shelf are in regions that have been uplifted or below maximum flooding surface events & vertical transfer of the porous units within inner shelf. Faults is one of the mechanisms for pressure seals.
ii. Two methods to test on predicting pore pressure (Eaton & Bowers) underpredicts overpressure magnitude. Optimization needs to be done to better predict pore pressure, based on the overpressure regime.
iii. Maximum possible hydrocarbon column length for Block A remaining potential of deep gas overpressured play, could be estimated based on optimized model in (ii).

1.5 Scope of Study

The scope for this study includes:

i. Geological interpretation of the area includes sequence stratigraphy, seismic facies interpretation & analysis, gross depositional environment (GDE) & structural evolution of Block A.
ii. Pore pressure prediction of Block A based available wells data by testing two methods (Eaton & Bowers), choose one of the best method to best represent the pore pressure model and optimize the pore pressure model to match the actual well data based on geological observation.
iii. Estimation of column length for remaining potential of deep gas overpressured play, based on Block A pore pressure regimes. Test the maximum column length with available deep gas overpressured play discovery fields within Block A.

1.6 Significance of Study

Pore pressure prediction is normally being done per wells basis and did not normally been done as regional scope. As such, regional overview of pore pressure has been neglected, hence overpressure surprise was not being expected for previous planned wells. Even if it’s been done as regional scope, only a few basin pore pressure studies examples found in the literature. This study is not only for reference for the future planned wells, it’s supposed to function as part of additional literature to pore pressure studies and understanding overpressure over local basin area and how it affects the risking on the remaining potential of deep gas play.

1.7 Chapter Summary

An effort to pursue pore pressure study has been initiated due to very limited understanding on pore pressure prediction of Block A, understanding the mechanisms of overpressure, designing optimized pore pressure model and to evaluate the remaining potential of deep gas play. The study will be done by defining sequence stratigraphy of Block A, develop gross depositional environment (GDE), horizon & structural interpretation, testing a few different pore pressure prediction methods with wells data available, select best method and optimized the pore pressure model based on geological observation & predict column length of the remaining potential of deep gas play. The study not only as part of pore pressure understanding improvement over Block A, it is also served as additional literature of pore pressure study over local region as well as additional value to determine column length on the remaining potential of deep gas play.

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