UNDERSTANDING OF RESERVOIR CHARACTERIZATION IN DEEPWATER ENVIRONMENT USING DEEP DIRECTIONAL ELECTRO-MAGNETIC MEASUREMENT TOOL

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To my beloved parents, my wife, my daughter, lecturers and fellow classmates.

Thank you for your unwavering supports and loves.

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In the name of Allah, the Most Benevolent, the Most Merciful. There is no power but from Allah.

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ABSTRACT

The last decade has shown a significant development in resistivity measurement technology providing directional resistivity at a larger scale than conventional logging tools. The latest development can identify resistivity contrasts ten's of meters around the wellbore. While the technology has been tested for almost a decade, this is the first time PETRONAS is applying the technology in Malaysia setting. It serves as important gauge of the tools application in the Malaysia deepwater environment in the future. The deep directional images provides information at a scale that bridges the gap between conventional logging and seismic and adds important new pieces to the reservoir characterization puzzle. In good reservoir conditions, resistivity contrast up to 30 m away from the well-bore has been observed.

ABSTRAK

Dekad yang lalu telah menunjukkan perkembangan yang ketara dalam teknologi pengukuran kerintangan menyediakan kerintangan berarah pada skala yang lebih besar daripada alat pengelogan konvensional. Perkembangan terbaru boleh mengenal pasti kerintangan pada kedelaman berpuluh-puluh meter di sekitar lubang telaga. Walaupun teknologi itu telah diuji selama hampir satu dekad, ini adalah kali pertama PETRONAS mengaplikasikan teknologi dalam persekitaran Malaysia. Ia berfungsi sebagai tolok penting pengaplikasian alat dalam persekitaran laut dalam Malaysia pada masa hadapan. Imej-imej yang berarah dalam memberikan maklumat pada skala yang merapatkan jurang antara pengelogan konvensional dan seismik dan menambah petunjuk baru yang penting untuk teka-teki pencirian takungan. Dalam keadaan takungan yang baik, kerintangan kontras sehingga 30 m dari lubang telaga telah diperhatikan.

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DDR	Deep Directional Resistivity
FDP	Field Development Plan
GOR	Gas Oil Ratio
MWD	Measurement While Drilling
LWD	Logging While Drilling
STOIIP	Stock Tank Oil Initially In Place
GIIP	Gas Initially In Place

CHAPTER 1

INTRODUCTION

1.1 Background of Study

Geosteering measurements that accurately predict oncoming strata in high-angle and horizontal wells are the dream of all well operators and an important responsibility for service companies. To perform this task, service companies have developed measurements that produce both wellbore images and petrophysical data. These measurements identify the structural dip of formations and characterize reservoir properties.

The depth of investigation of these measurements are typically no more than a few centimeters from the wellbore, and are therefore limited to mapping only the first nearby geological boundary. A new deep electromagnetic (EM) logging-while-drilling (LWD) tool currently in field test extends the depth of investigation to 30-m or more from the well bore.

The depth of investigation provided by the new LWD tool allows detection of multiple strata over long horizontal distances. The new measurement system allows identification of multiple resistivity layers that correspond to different geological interfaces. This detection capability gave a high level of confidence in the geosteering process. Not only did the measurements improve the correlation between geological markers, but they also attracted the attention of the reservoir geologists who used these observations to map geological features. To date, our experience with the new deep EM LWD tool has allowed us to map a sandstone pinch out, map a region influenced by the washout of water injection in the field, delineate reservoir continuity, and identify a sub seismic fault.

These types of heterogeneities are important features that impact fluid flow and our understanding of the reservoir. The data delivered by this new LWD tool provides more geological information than any other technology currently available in the market. This technology provides valuable information that can be used by geologists and operational engineers to map and monitor the reservoir.

1.2 Problem Statement

For PETRONAS, the “T” field presented a significant drilling challenge. The operator’s target—the turbudite sandstone “T” reservoir—was 7–16 ft [2–15 m] thick, comprising discontinuous sand, and thin interbedded layer and dipping structure. This makes determining the exact stratigraphic location of the sand difficult. Accurate reservoir steering is, therefore, of the utmost importance for optimal well positioning. The main problems in completing the “T” field is outlined and as per following:

1. To map complex reservoir with discontinuous sands, turbidite and structure dipping to position future drain trajectory, steer aggressively to connect discontinuous sand bodies, and while avoiding shale and maintaining oil/water contact standoff, without exact knowledge of reservoir depth.
2. To map internal variations of reservoir structure to improve geological interpretation and enable further understanding of its nature and depositional history for optimized field development.
3. Limit confidence for required timely trajectory adjustment for complex geology (due to sudden structural dip).

1.3 Objective

Case study of "T" field will highlight why deep directional resistivity is a step change related to the possibility for doing pro-active well placement of highly deviated wellbores as well as for gaining a larger reservoir understanding. The imaged variation in resistivity contrasts can be related to geologic zonation and fluid content on the reservoir scale, which opens up a much better cross-disciplinary communication between geophysicists, geologists, petrophysicists and reservoir engineers. Finally, the deep resistivity images contribute in optimization of completion solutions when incorporating information on the reservoir scale. Towards the end of the project, these grounds are to be covered:

1. Optimize production in targeted layer
2. Combine deep directional electromagnetic measurements from Deep Directional Resistivity (DDR) tool with seismic data to improve reservoir interpretation, land well, and make real-time steering decisions.
3. To introduce new tech solution to reduce uncertainties in steering decisions.
4. To reveal the geology uncertainty in target study area by using DDR tool
5. To understand a better well placement method in landing the well & steering in lateral section.

1.4 Scopes

This study will focus on results from the “T” fields, and will demonstrate how the device was used in a range of different applications in the geosteering operation:

1. Detection of the reservoir boundary up to 20m TVD away.
2. Detection of oil bearing reservoir from within underlying shale, through a water zone.
3. Detection of Gas-Oil Contact (GOC).
4. Detection of Oil-Water Contact (OWC) up to 20m TVD away.
5. Detection faulting of the reservoir.

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