Characterizing the Clay Particle distribution in Deepwater Channel Levee Complex using Borehole Micro Image and Multi Triaxial Induction Measurement: A Case Studies from Eastern Offshore India


Summary

The present study shows an Integrated Approach of Formation Evaluation combining the Multi Triaxial Induction Measurement and Borehole Image log. Using the Dip data and Borehole Image log paleo-depositional environment is constructed. Once the paleo-depositional environment is understood, the probable distribution of clay particle within sand body is characterized from Image log as well as from Triaxial Resistivity Measurement. Finally clay particle distribution pattern is characterized in different paleo-depositional environment of Deepwater channel Levee Complex.

Keywords: Borehole Image, Multi Triaxial Induction Measurement

Introduction

Clay Particle Distribution Pattern in sand is a crucial factor for understanding the fluid flowing capacity and producibility of the reservoir. Today with the advance in technology new measurements can be obtained and processed in a way to understand the inherent clay particle distribution pattern within the reservoir. The present work showcased the application of integrated result from borehole Image log as well as multi-array triaxial induction tool to understand the reservoir heterogeneity in deep water channel levee sand. This approach is illustrated in two examples from deepwater of Eastern Offshore basin of India which were penetrated through a thick sedimentary sequence. The first well was drilled vertically and the second well was sidetracked from the main vertical well to reach a target of around 2 Km away from the first well. Dip information of the sedimentary sequence was critical in addition to the resistivity anisotropy for better correlation and detailed formation evaluation. Main borehole hole has only Triaxial Resistivity data along with basic openhole data, whereas, Triaxial Resistivity was planned to be acquired in the side-track well along with the high resolution Borehole Imaging data, which was acquired over the reservoir section only.

Theory and Methodology

The present study is an integrated approach from Borehole Image log and Triaxial Resistivity Tool.

Borehole Imaging Technology:

The Borehole Imaging Tool used in this study has four pads on four arms spaced at 90 degrees around the borehole. On each pad, five pairs of sensors are placed between current Electrodes. The five resistivity measurements from each pad can be displaced as a five pixel wide image of the formation resistivity at the borehole wall.

The images from this well are of interest in two counts. The first is that these images can be used to determine the formation architecture through stratigraphic/structural interpretation and visual characterization of reservoir facies. And the second count is that the images, help in understanding the clay particle distribution in different sedimentary unit.
**Multi Triaxial Resistivity Measurement:**

The new multi-array triaxial induction tool gives additional information about anisotropic formations at different depths of investigation that are independent of formation dip or hole deviation. This tool consists of a fully triaxial transmitter, three axial receiver arrays, and six fully triaxial receiver arrays.

Real-time wells site algorithms provide formation anisotropic resistivity, invasion parameters, dip and azimuth, as well as standard array induction logs. Further inversion processing of the data at the computing center provides high-resolution anisotropic resistivity.

Moreover, apart from anisotropy petrophysical evaluation, this tool has applications for dip determination in development wells (along with the standard resistivity logs) and for obtaining fully environmentally corrected formation resistivity at any dip or deviation angle.

The methodology adopted in this study is an integrated approach combining the Dip data, Image Textural result and Clay Particle Distribution pattern from Image log and Multi Triaxial Resistivity Tool.

The first step of this study is the Data Processing for Dip Interpretation from both the tool. Then Dip data correlation in both the well and Geological environment interpretation from Image log, OH log and Dip data. Finally Clay particles distribution is conceptualized along the well and across the well in different sedimentary facies existing within the Deep water sedimentary environment.
Characterizing the Clay Particle Distribution Pattern

Fig 2: Structural dip validation of Triaxial Resistivity dip data with Borehole Image derived dip data
Characterizing the Clay Particle Distribution Pattern

Fig 3: Paleo-Geological environment determination
Characterizing the Clay Particle Distribution Pattern

Fig 4: Different sub-environment of Deep Water Channel Levee Complex.

Fig 5: Sedimentary Facies correlation
Fig 6: Dispersed to Laminated clay particle distribution in Distal Levee Sand.

Fig 7: Dispersive to Laminated clay particle distribution pattern in Medial Levee Sand.
Results and Discussion

The main vertical well was drilled through a long sedimentary sequence. Array Induction data and Borehole Imaging data provided the structural dip, horizontal and vertical resistivities and textural analysis data. This resistivity analysis results was useful in enhancing formation evaluation. Detailed dip analysis was performed over the entire interval. It has also been found that the triaxial resistivity dips were in agreement with the interactive dips derived from the borehole image tool in the common section. Validation of triaxial resistivity measurements with borehole image dip data established a higher confidence in determining dips for the entire interval, as well as, the borehole where borehole image log data is not available. Further, using this dip data and the image texture a conceptual paleo-depositional model is established. It was found that the borehole has cut through different parts of Deep Water Channel Levee complex starting from a channel base, proximal levee, medial levee to distal levee. Keeping this geological paleodepositional model in the backdrop, clay particle distribution pattern in different part of the deepwater channel levee complex is characterized with the help of textural analysis from triaxial resistivity measurement. It is observed that the clay particle distribution shows little bit of laminated in nature in proximal levee part where sand content is higher. In the medial levee part the shale content is increasing and the clay particle distribution pattern is observed dispersive to Laminated in nature. Where as in the distal levee part the clay content is increasing in considerable amount and the clay particle distribution pattern is mostly laminated in nature.

Reference


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