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Unconventional Reservoir Facies Modeling using Conventional Logs and Micro Resistivity Imaging Technique

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Summary

Syn-rift sandy conglomerate reservoir of Cambay Basin was studied in detail to understand the potential unconventional reservoir facies that is contributing to hydrocarbon production along with its overall lateral extent for volumetric estimation. Identifying complex depositional facies through conventional wireline data levies key challenges if the facies are mostly driven by textural feature. On the other hand, incorporating high resolution image log data is simply not enough in identifying formation heterogeneity that are essential for unconventional reservoir facies. To overcome the hurdle, an innovative approach was adopted by integrating classical neural network analysis with the bin distributions of high resolution micro resistivity image data that has been satisfactorily classified unseen textural facies and further formation heterogeneity those are significantly contributing for hydrocarbon production of Cambay Basin.

Introduction

In a rift-basin, shallow marine sandy, conglomeratic and cretaceous fracture basement reservoirs are normally considered for potential hydrocarbon reserves. Determination of sub-seismic reservoir vertical and lateral facies distribution within tectonically disturbed terrain always imposes immense challenges when treated with a conventional approach. To overcome this, a new two-phase workflow has been adopted to establish vertical facies distribution in unconventional reservoir.

Study Area

The present study has been carried out in the Cambay Basin in, western part of India (Fig. 1). The Cambay Tertiary basin is an intra-cratonic basin that came into existence at the close of the Mesozoic period by the development of tensional faults along its margins that accompanied by large-scale volcanic activity (Raju, 1968). Thus, the basin comprises of basement, trapwash conglomeratic facies superimposed by shale, siltstone and sandstone along with occasional presence of coal layers. This study was mainly focused in Paleocene to Eocene age of rocks.

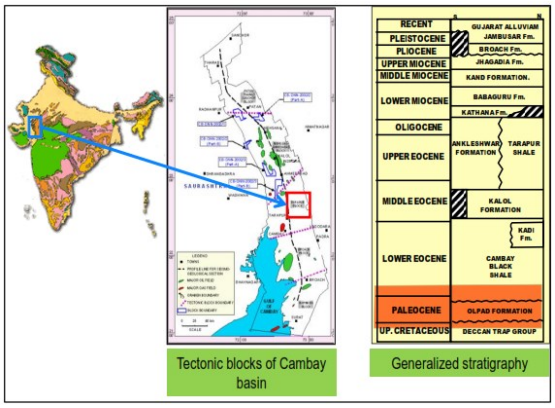

Fig. 1: Study area and generalized stratigraphy (after Chandra & Chowdhary 1969) of Cambay basin India.

Challenges

The major challenges encountered are as follows:
Deposition of in-situ basement derived clasts with terirgenous sediments from different sources resulted in to complex litho facies.

High relief due to horst graben structure consequences in to debris flow type of deposits in rift basin

Identification of textural based image facies using conventional logs

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Workflow

To address the above-mentioned challenges, a new two-phase workflow has been adopted in order to establish vertical facies distribution in this unconventional reservoir (Fig.2). In the first phase of the workflow, open hole conventional logs were used in identification of distinct petrophysical facies using a neural network method. Initial goal was to find a projection between the sample learning space and a down-sampled solution space by preserving original topology space. A hierarchical clustering approach was adopted for facies classification that helped in choosing the optimum number of facies classes in unsupervised mode (Fig. 3).

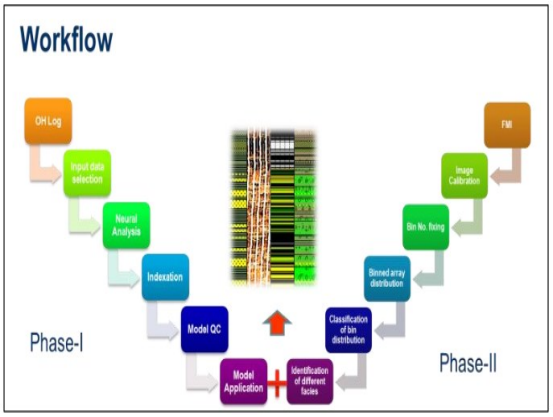

Fig. 2: Two-phase workflow

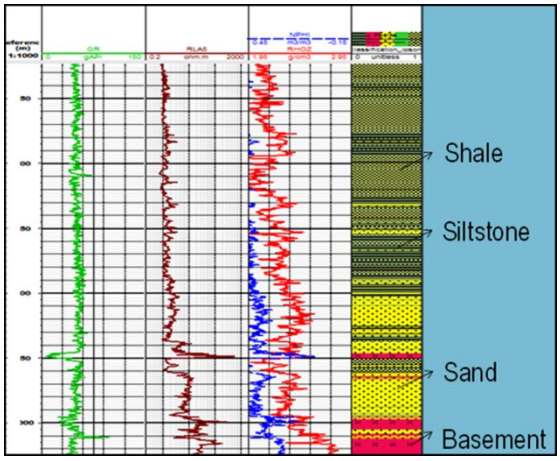

Fig. 3: Facies interpreted from basic logs using EPSOM in Techlog

Since open hole conventional log data reads the formation in terms of overall vertical average responses, it increases the possibility of hiding finer textural details such as in basement derived conglomerate formation (Fig.4).

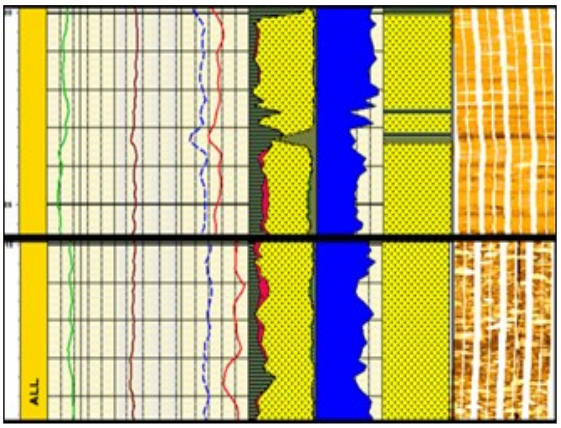

Fig. 4: Unsupervised model shows similar response against conglomerate and sandstone.

A completely new technique using high resolution resistivity images was blended in the second phase of the workflow that played significant role in identifying texturally based sedimentary facies. It comprises of mapping of different bin sizes of micro resistivity image log data that illustrates volumetric representation of respective bins. When the distribution reflects significant contributions from each bin interval, formation heterogeneity was interpreted. On the other hand, in case of more than eighty percentage of dominance, the distribution indicates formation homogeneity (Fig. 5).

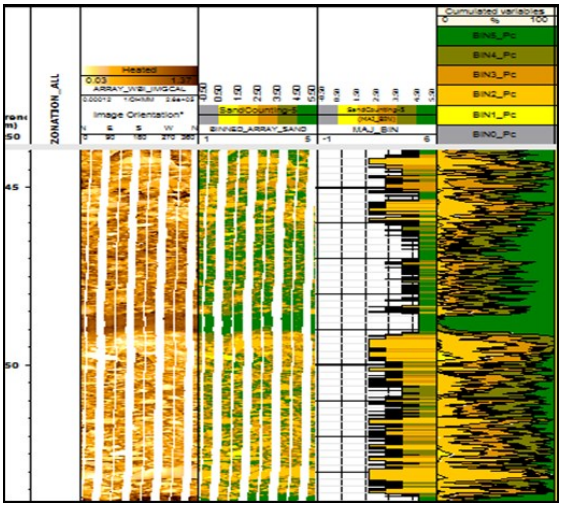

Fig. 5: Resistivity bin distribution to identify textural variation

Micro resistivity image enhances the clarity of textural basis facies and based on this concept, another conditional function has been applied on bin distribution to generate arrays of curves which represent conglomerate sub facies namely sandy and muddy matrix-supported conglomerates.

Finally, the results from phase one and phase two were combined. The results identified seven types of facies classes in total. Four out of first five facies were identified by openhole logs and those are sandstone, shale, siltstone and basement. A fifth facies has been considered as unknown. Further, two facies have been identified by image log and they are mud supported conglomerate and sand supported conglomerate.

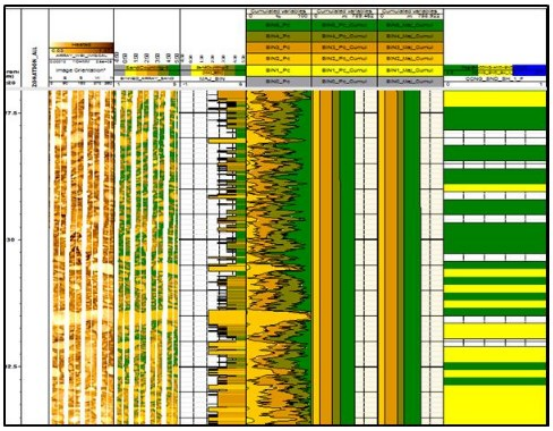

Fig. 6: Identification sand and mud dominated conglomerate Results

Results

Finally, the results of both the phases were combined together to make a hybrid facies classification. As an outcome, a couple of textural facies was identified in addition to five distinct litho-facies interpreted from neural network analysis. The study actually revealed the sand facies and also the sandy matrix supported conglomerate (Fig.7), which is very irregular in thickness, have significant commercial prospective which later supported by production data. The results were also helped in establishing the lateral variation in terms of clasts size which further helped in understanding of tectono-sedimentation process and depositional environment to identify the possible extent of potential unconventional reservoir facies (Fig. 8).

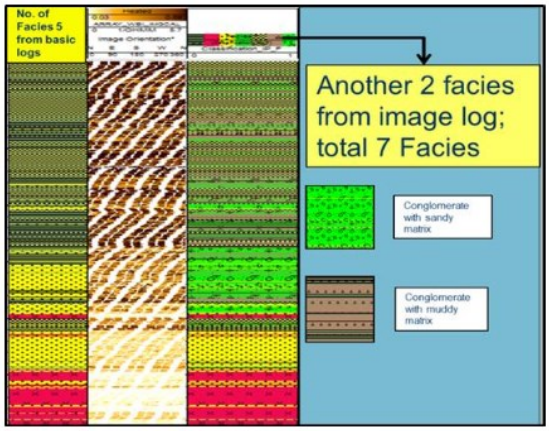

Fig. 7: Identification of classified conglomerate along with conventional facies

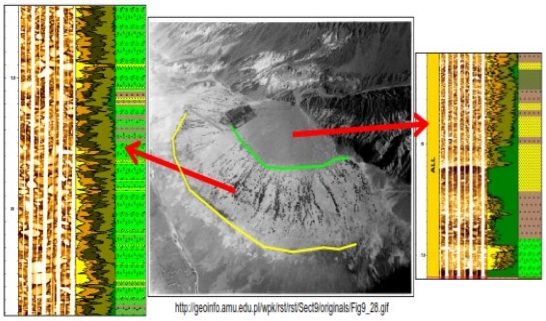

Fig. 8: Figure represents lateral facies variation and analog alluvial fan depositional setting.

Conclusions

Couple of unconventional reservoir facies was identified by introducing hybrid classification technique where bin distribution of high resolution micro resistivity image data guided the neural network technique that were absent previously with unsupervised neural network analysis using conventional wireline log data. Result was verified and validated with production data and lateral extent was delineated by studying multiple wells for gross reserve estimation.

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Reference

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