Understanding the High Resolution Facies Variation in Cretaceous Carbonates with Image Logs and Neural Network: A Multi-well Study from Offshore Abu Dhabi

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Abstract

The Thamama Carbonates are being produced from Offshore Abu Dhabi for a long time; however, the inherent heterogeneity continues to throw surprises when studied in the context of high resolution facies variation. Selective diagenetic changes seem to have left their imprint in form of highly variable reservoir properties even within the same depositional environment. A four-well study was undertaken to understand the facies variability at highest resolution with the help of image logs and robust neural network application on a very gentle carbonate ramp. The study-wells are roughly aligned in a NE-SW fashion; along the structure within grossly the same depositional setting. However, the alternating porous and hard limestone layers exhibit subtle variations amongst the wells; that can partly be attributed to the sub- environments but mostly to the diagenetic variations. The heterogeneity on the borehole images is studied in three wells in detail; and all the subtle variations are listed for comparison against the distribution of wells in the field.

In the clean carbonate intervals, the conductive heterogeneities are inferred to be associated with porous intervals and the resistive heterogeneities are due to dense cemented areas of lower porosity (dense limestone). The vuggy porosity distribution showed interesting trends; where for similar vuggy porosity, different permeability indicators were observed based on the connectedness of vugs. Though the wells are not far off and exhibit similar distribution of vugs mould-sizes; a remarkable change in the connectedness through them is observed that can be related to a second phase of diagenesis.

Based on the relationship of high resolution facies variation in three wells, a neural network is trained to predict the heterogeneity in the fourth well honoring the geological understanding developed. The results were further integrated with core. This neural network classification adds a big value in this study to predict the facies variability in other wells where image logs are not available. Also, this provides a base for constraining further petrophysical modeling away from the well-control in the field. This study, therefore not only helps in understanding the geological variations at high resolution, but also provides a workflow to predict and estimate facies variability on a field-scale in Offshore Abu Dhabi carbonates.