Paper ID-2004557

Petrophysical Evaluation and Resrvoir Characterization of Olpad Formation- A Volcanoclastic Reservoir in Cambay Basin

Rajesh Chandra #, B. K. Saikia and Dr (Lt. Col.) K.J. Singh

CEWELL, ONGC, Vadodara,Gujrat, India-390009

Presenting Auther Email : chandra_rajesh@ongc.co.in

Abstract

In this paper, attempts have been made to develop a suitable methodology for evaluation of Volcanoclastic formation and reservoir characterization by identifying different facies based on mainly resistivity image log together with other logs as well as core data. Facies and mineralogical analysis is done using high tech logs, log crossplots, histograms and integrated with core studies and depositional environment envisaged. With this integration, a suitable petrophysical model has been developed and reservoir parameters are estimated with this model.

Introduction

The Mansa area is located on the eastern flank of the Cambay Basin (Fig-1) where a thick sequence of volcanoclastic is deposited. Evaluation of volcanoclastic reservoir poses challenge due to its complex mineralogy. The Olpad formation deposited mainly in lacustrine / continental environment during the syn-rift phase of rift development. The syn-rift sediment of the Olpad formation predominantly comprises trap conglomerate, trap wacke and trap wash sediments.

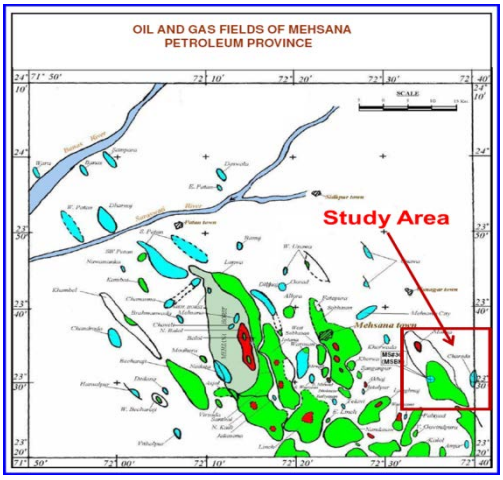

Fig-1

Exploratory well-A produced good amount of oil (25M^3/D, bean-5mm) from Olpad formation but two development wells (B and C) did not produce as per expectations. Other two Exploratory wells (D and F) are also producing oil from Olpad formation from a zone having different type of facies as in well-A. The present study is an attempt to evolve suitable methodology for evaluation of such volcanoclastic for effective reservoir characterization.

Volcanoclastic facies from logs

Fig-2 is the image log of the zone in well-A, which produced 25 m3/d of oil on initial testing. The image log clearly depicts the conglomeritic nature of the formation. It is mainly consists of pebble to cobble size conglomerate, of rounded to sub-rounded in shape, supported by grains of granule to probably sand size. The corresponding log nature on neutron, density log are shown by cluster of points by inner red (solid) sub-enclosure within red (dotted) enclosure (Fig-3). The remaining clusters of points within dotted red enclosure correspond to other tested zone which produced poor influx of

water with traces of viscous oil. The image log in Fig-6 depict the poorly sorted fragments of all types from boulder to granule size indicating poor reservoir character. High bulk density against the image interpreted poorly sorted zone can be explained by the fact that the pore space is mostly filled with smaller fragments. Fig-7 which is a cross plot of bulk density vs. resistivity clearly brings out the two facies as discussed above. Cluster-A (Head part) mainly corresponds to producing facies whereas cluster-B represents the poor reservoir characters of other tested interval. The head (high resistivity) of cluster-A corresponds to conglomeratic facies with good reservoir characteristics while the tail corresponds to non-reservoir shale points.

Olpad section in well-D can be divided into three sections. The top section is characterized by layers of shale with volcanics and almost in equal proportions. The volcanic layers have higher gamma-ray and comparatively higher density than shale section. Fig-8 is the FMI image log of cored interval in this section. The cored interval is mainly reported to be consists of trap conglomerate, trapwacke and claystone. According to core report the trap conglomerate comprises of very coarse gravel to cobble sized (1 cm to 4.5 cm) rounded to sub-rounded fragments and sand-silt size material in fine grained matrix. The visual porosity is moderate. The trapwacke is reported to contain sand sized particles of altered basalt of shape sub-rounded to sub-angular. The core analysis is in consistent with image log (Fig-8), which is also showing fragments of size of about 0.4" to about 2" (right side image) and sand-silt size material (left side image). The overall reservoir quality is poor as compared to well-A (Fig-2). Zone tested in this part of Olpad reported influx of oil@3.5 m3/dl. This section may represent distal part of fan. The middle part is mainly shale/ claystone (trapwash) with zones of few trap fragments embedded in clay.

The lower section is characterized by high resistivity, high gamma ray, high density & comparatively lower neutron readings as compared to upper two sections. Fig-9 depicts the resistivity images characteristics of this section. The images show that the sediments is ill sorted comprising of fine cobble to gravel size subangular fragments embedded in finer fragments. The sediment can be termed as trapwacke. The formation appears to be hard, cemented and compact as such and drilling induced fractures are observed. Testing of this section resulted in influx of 8.87 m3/d oil. The reservoir quality can be considered as moderate to poor.

The neutron–density cross plot (Fig-4) shows that unlike well-A & E, (Fig-3 & 5) the green points (representing certain resistivity range) do not go density value below 2.4 gm/cm3, indicating deteriorating nature of reservoir character.

Fig-10 depict the log motifs of the upper part of Olpad section encountered in well-E. The image logs bring out very poorly sorted conglomeratic facies character. The conglomerate is generally consists of cobble to pebble size subangular fragments. The blurred nature of the static image in Fig-10 indicates probably the diagenetic effect by cement. The reservoir quality, in such situation, generally becomes inferior. The initial testing result (Influx of 9 m3/d of oil from top part and influx of 3 m3/d of oil from bottom part of this zone) supports the above conclusion regarding the quality of reservoir.

The neutron-density cross-plot (Fig-5) shows three resistivity clusters (differentiated by color code (red, green & blue) of Z-parameters in the form of resistivity) in well-E against two resistivity clusters in well-A (Red & green) (Fig-3). The third cluster (blue color) with high density – high resistivity correspond to diagenetically cemented section. The green cluster in both the wells roughly corresponds to reservoir section.

Different Electrofacies are also generated using conventional logs like density, neutron and resistivity logs by cluster analysis method (Fig-11). Electrofacies thus generated are correlated and validated with FMI image and testing data. Identified five electrofacies from this analysis are 1) Good reservoir facies (Conglomerate-1), 2) Moderate reservoir facies (Conglomerate-2), 3) Tight reservoir facies (Conglomerate-3), 4) Silty-poor reservoir facies (Trapwacke) and 5) Shale facies (Trapwash).

Mineralogy and Petorphysical Model

The main clay minerals reported by X-Ray Diffractometric study on cores of well-D at RGL, ONGC, Vadodara, are kaolinite and montmorillonite.
Fig- 3, 4 &5 shows the end points, corresponding to minerals present in the formation, which causes dispersion of the points. Using information from the cross plots, petrographic and XRD analysis of core data and other geological information, a multi minerals/ rock model comprising of i) kaolinite and ii) Montmorillonite as clay minerals along with iii) SM1 (representing mixture of high density mafic minerals present in volcanoclastic) has been considered for processing. Optimum values of log parameters for these constituents are obtained by minimizing difference between reconstructed and recoded log curves.

Petrophysical Evaluation and Reservoir Parameters

Using above Petrophysical model, quantitative formation evaluation is carried out in 10 wells, to see the efficacy of the petrophysical model chosen and its validation. Reservoir parameters are also estimated in these wells.

Conclusions

- Resistivity micro-image log able to identify different facies in Olpad Formation, such as, trap conglomerate, trap wacke, claystone/shale etc. On the basis of facies identified on Image logs as well as by cluster analysis the Olpad formation is interpreted to be deposited in an alluvial fan system.
- The upper part of Olpad in well-A was deposited as well sorted channelized conglomerate (sieve deposit?) while the upper part of Olpad in well-B & C is argillaceous and interpreted as overbank deposit during flash flood.
- The lower part of Olpad in well-A, B & C are deposited as poorly sorted channelized conglomerate.The inter-bedded shale in Olpad formation in these wells were deposited as slack water deposit during waning period catastrophic flow.
- An alternate interpretation of presence of shale could be the repeated switching of channel course laterally to and fro over a period of time depositing conglomerates over overbank fine deposit and vice versa.
- Well-A, B & C are located in the same fan system (Fan-1). Presence of well-rounded conglomerates and argillaceous facies indicate them to be part of mid fan. The channels were flowing from east to west.
- Well-D belongs to a same fan system (Fan-1) but located at distal part of it. The fragments are smaller in size and deposited as debris flow (unconfined?).
- Well-E belong to different fan lobe (Fan-2) further south of well-A fan lobe (Fan-1) and deposited as proximal fan probably as unconfined debris flow.
- Based on the model locale of better reservoir facies may be available in eastern and western direction of well-A along channel direction.
- A mineralogical model comprising of mafic high density mineral, kaolinite and montmorillonite was found to be sufficient for a reasonable formation evaluation.
- The estimated porosity and water saturation are 15% and 48% in well-A and 13%, 50-61% & 12-15%, 57-62% in well-D and E respectively.

References

1. Depositional Environment of Olpad Formation in the Flank of Cambay Basin, C.L.Chaudhary, A.N. Pandey; RGL, ONGC, 1988-89.
2. Olpad Formation – Analysis and Hydrocarbon Prospects in Mehsana Area, Cambay Basin, Gujarat, C.P. Gavarshetty, Asish Kumar, M.K.Samanat, Geplogy Division, EBG, ONGC, Mehsana, 1993
3. A Note on the Lithological Analysis of Olpad & Cambay Shale Formations in North Cambay Basin, – by Dr P.V.L.P. Babu, T.R.Prasad, Synergistic Exploration Group, EBG, Vadodara; 1985.
4. Well Completion Report (WCR) of all the wells studied in this area.

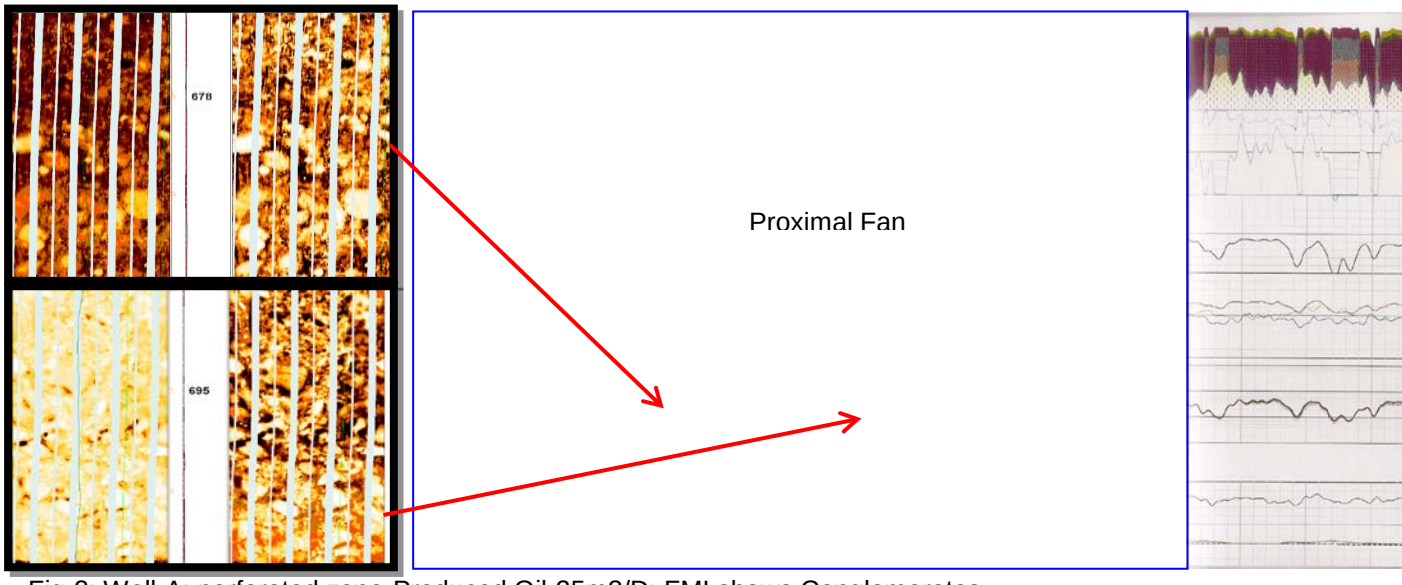

Fig-2: Well-A; perforated zone-Produced Oil-25m3/D; FMI shows Conglomerates

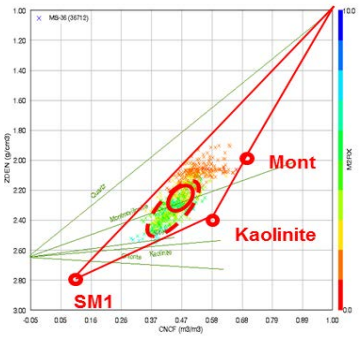

Fig-3 (Well-A)

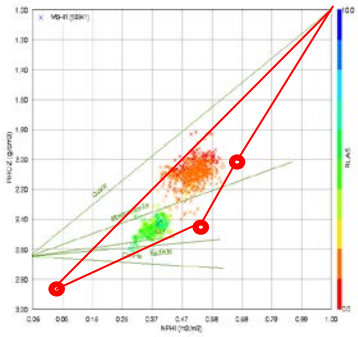

Fig-4 (Well-D)

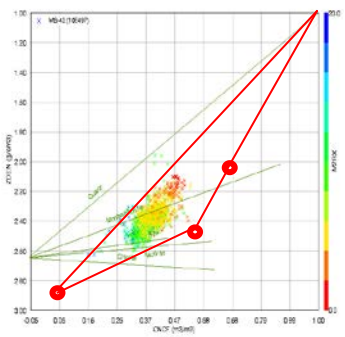

Fig-5 (Well-E)

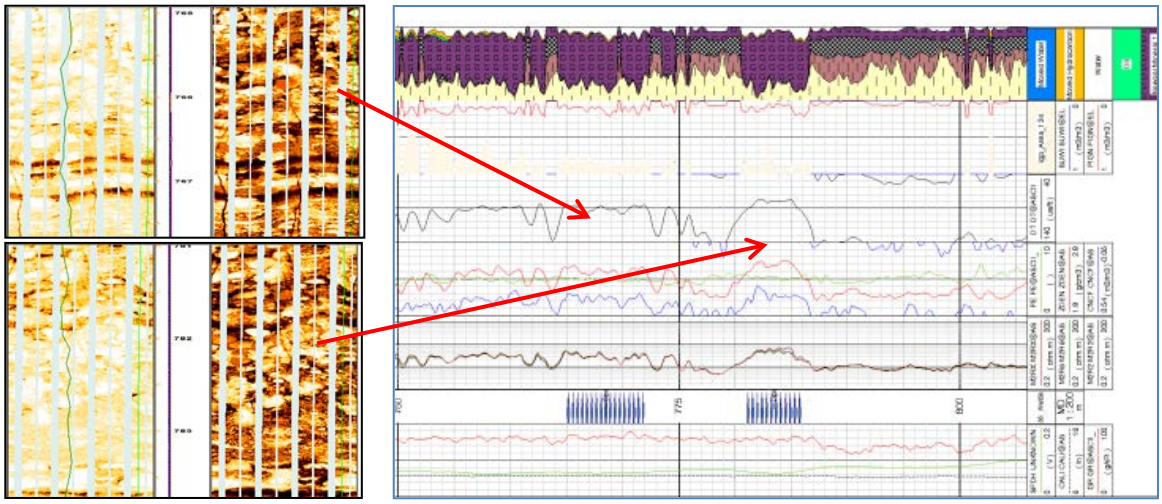

Fig-6: Well-A perforated zone- produced poor influx of water with traces of viscous oil)

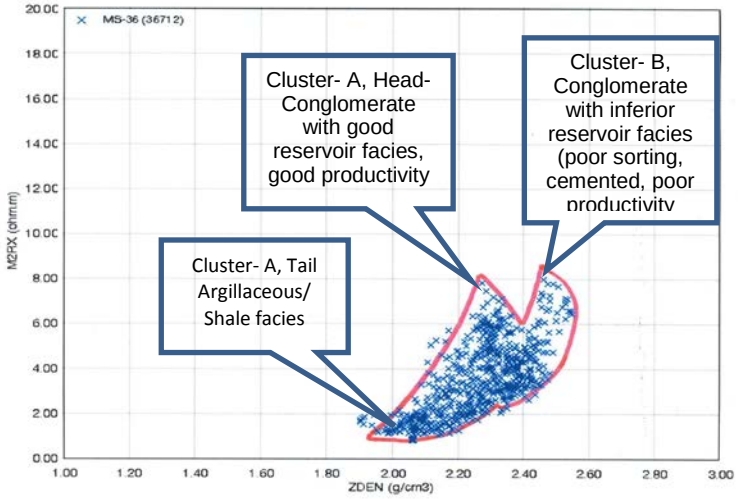

Fig-7: Well-A; showing two clusters on Resistivity-Density cross plot

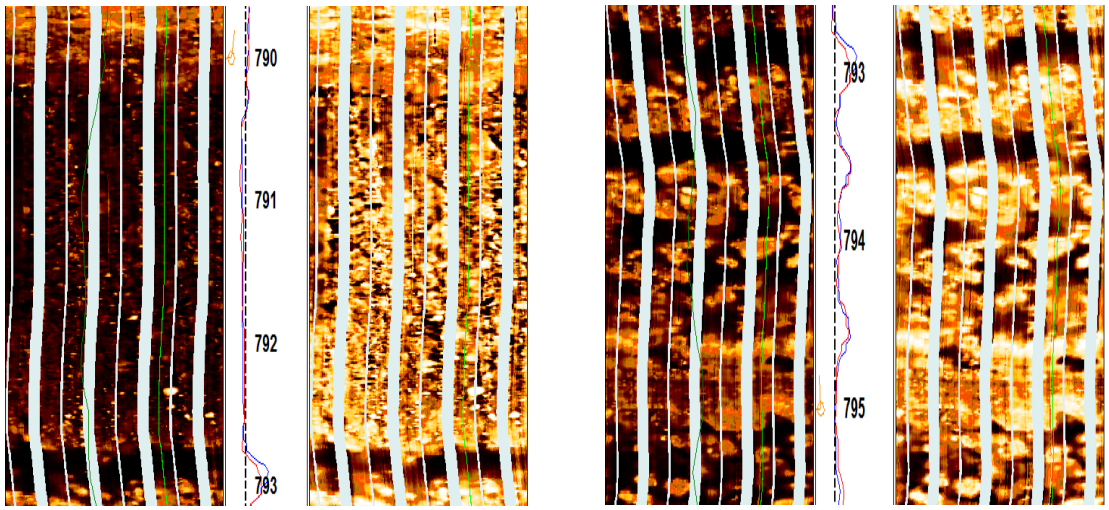

Fig-8 (Well-D: Images of cored section)

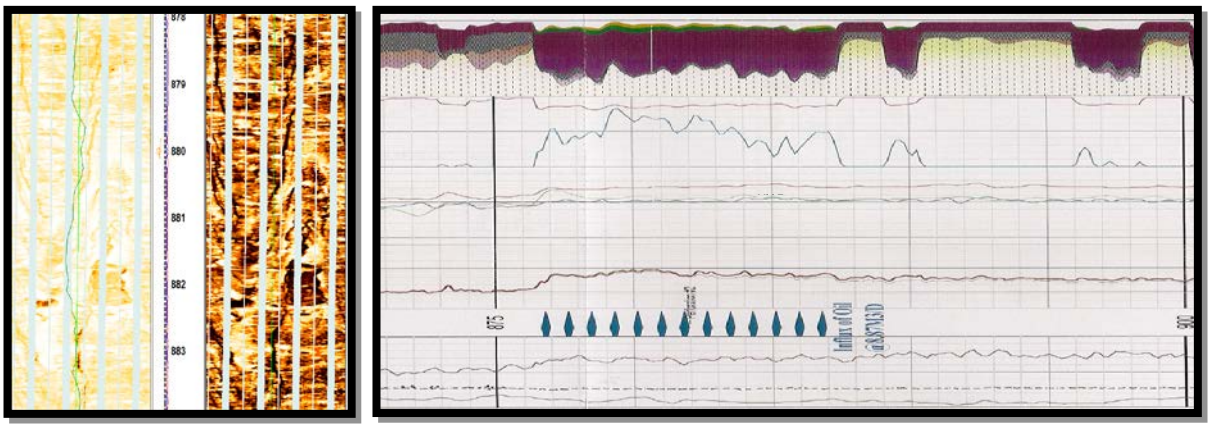

Fig-9: FMI log of Well-D; shows Trapwacke facies with drilling induced fractures indicating maximum horizontal stress direction in NE-SW direction

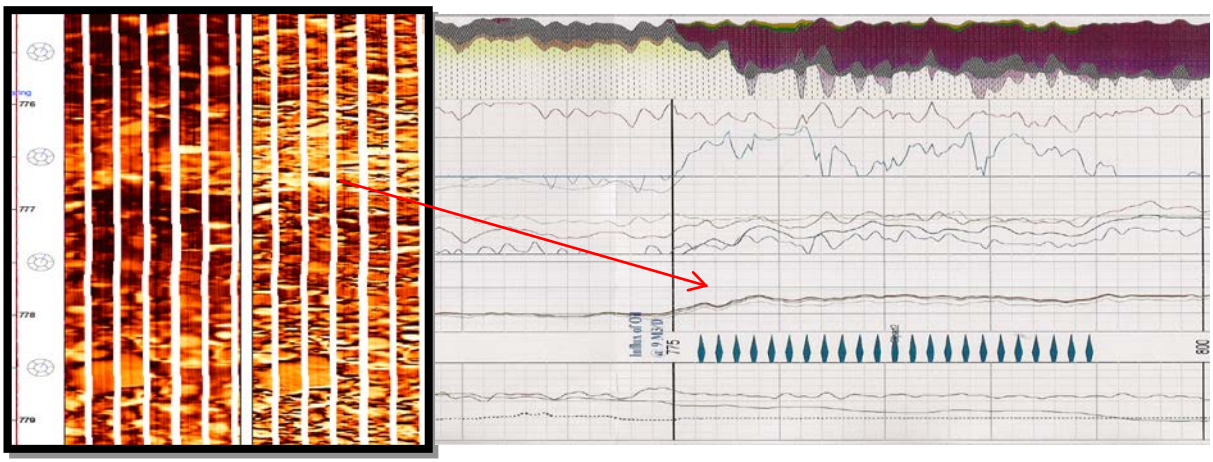

Fig-10: XRMI log of Well-E; shows Conglomerates in Proximal Fan

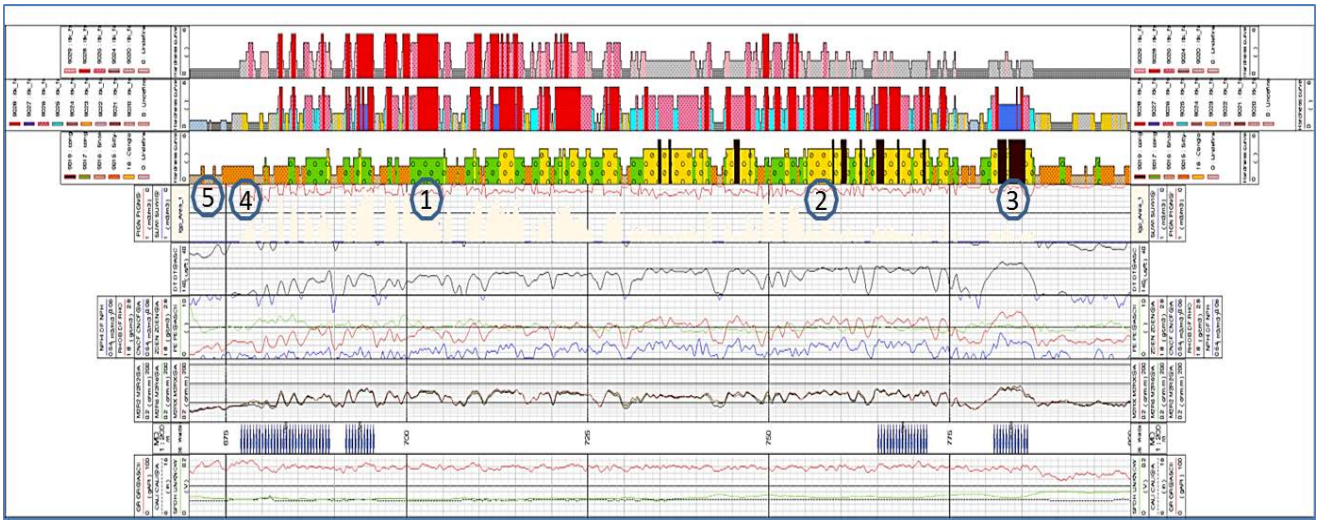

Fig-11: Well-A; Five Electrofacies-1)Good Reservoir, 2)Moderate Reservoir, 3)Tight Reservoir, 4)Silty- Poor Reservoir and 5)Shale (Trapwash)