9th Biennial International Conference
& Exposition on Petroleum Geophysics

"HYDERABAD 2012"

P-483

Delineation of pinch-outs within Panna Formation of Paleocene-Early Eocene sequence in and around South Mumbai Low to Identify Prospective Areas - A Case Study

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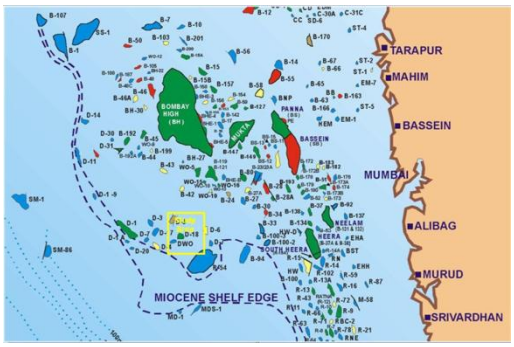
Summary

The Paleocene- Early Eocene sedimentary sequence of the Mumbai High – DCS area of Western Offshore Basin of India witnessed large thickness of silici-clastic deposition. This is evidenced in the southern part of Deep Continental Shelf (DCS) area, in the South Mumbai Low where more than 1000 meters of rift fill clastic sediments are piled up which show up-dip terminations against the basement rise. This is clearly revealed by the seismic data. Differentiation along the east – west faults flanking the southern low as well as the tilting of the basement has accommodated the low which gradually got filled and the fan system stepped back to the upper terraces. Continuing transgression then established in the deeper parts made the coarser clastic deposition back-step towards the highlands and finer sediment plumes to disperse away from the coast. Thus, the back-stepping up-dip clastic wedge-outs/ pinch-outs of the Paleocene- Early Eocene Panna Formation of the DCS area, in principle, should provide ideal reservoir conditions all around the periphery of the South Mumbai Low as it is taken as the main hydrocarbon kitchen of this area – even for the Mumbai High Field. The study brought out three such pinch-out limits within the Panna

Keywords*: Mumbai offshore Basin, Attribute analysis*

Introduction

The area of study lies in the southern part of Mumbai High-DCS, Western Offshore Basin of India (Fig. 1). The study area encompasses seismic data of WO-5 & 15, B-42, D-33, D-5 out of which the southwestern part, in which D18 field lies, has been studied in details. The analysis is focused to explore the prospectivity of Early Eocene- Paleocene formations Panna clastics. The wells of WO-5, WO-15/16 and D-33 are proven hydrocarbon producers from the Panna clastic sequences from different stratigraphic intervals. All these fields are on the northwestern and northern periphery of the South Mumbai Low.



Stratigraphy

Upper Cretaceous Deccan Trap basaltic flows form the Basement in this area. Although none of the wells in the study area have penetrated the basement, this has been inferred from the seismic. The Basement is unconformably overlain by Paleocene – Early Eocene Panna sediments.

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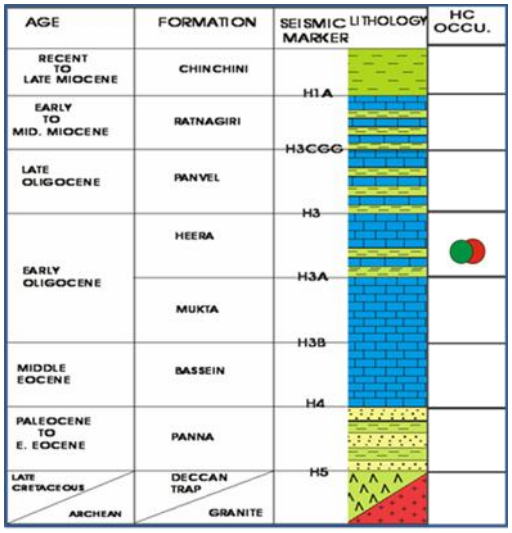

The Panna formation shows presence of **syn-depositional** clastic sedimentation in shallow marine to transitional environment. This is followed at places by Devgarh carbonates during the transgressional phase. The general stratigraphy is given in the following table.

Present Study

The primary objective of this study is to look for possible wedge-outs and pinch-outs within Panna formation. These can be targeted for hydrocarbons at favorable structural/ stratigraphic locales all along the periphery of the South Mumbai Low. Seismic interpretation was done in all the latest 3D volumes available at and around the south Mumbai Low (figures 2). Specific emphasis was given to the section corresponding to Panna formation and a number of reflectors coinciding with the D-33 and WO-15 Panna pay were mapped in all the volumes.

The reflectors within Panna are seen pinching out / wedging out towards the rising flanks of the South Mumbai Low in all directions (figure 2).The youngest wedge-out i.e. Panna Top is seen abutting against the Basement in the WO-15/16 area. Very near to this wedge out limit a number of wells producing from the youngest Panna clastics are present in both WO15 and WO16 area. Similarly, the stratigraphically older wedge-outs and pinch-outs can be targeted for exploration (figure 5).

The lowest reflector, below which the seismic signature is patchy, has been taken as Basement top.

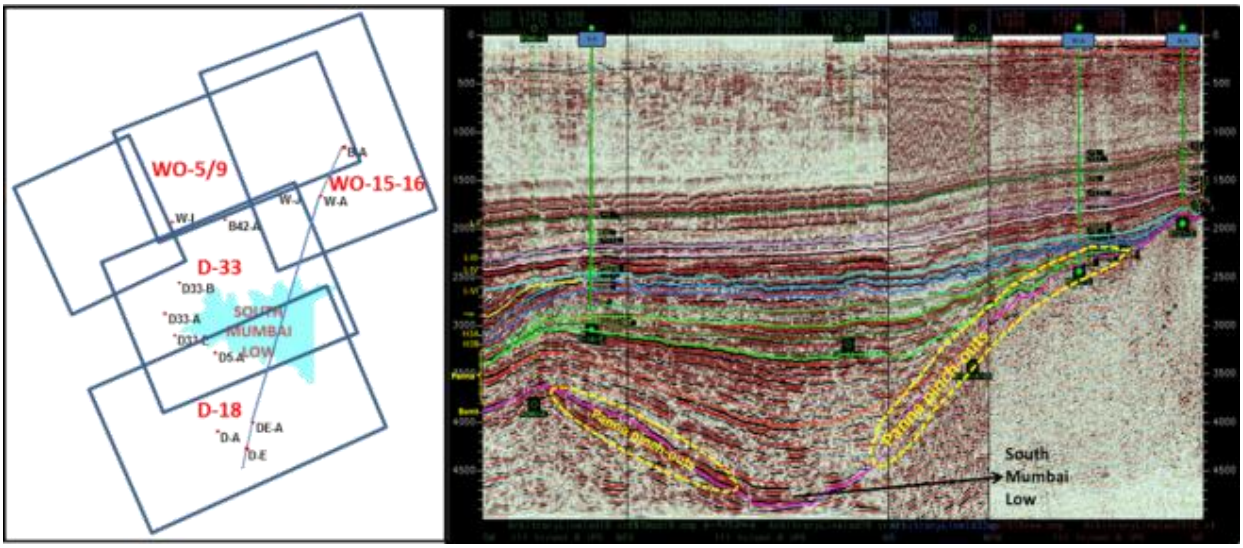

Figure 2: Map showing 3D vintages used for analysis, position of South Mumbai Low, with Arbitrary Seismic line from D18 wells to the southwest and WO/ B119 wells to the northeast across the South Mumbai Low and the horizons correlated within Panna along with the pinchouts on both sidec of the low

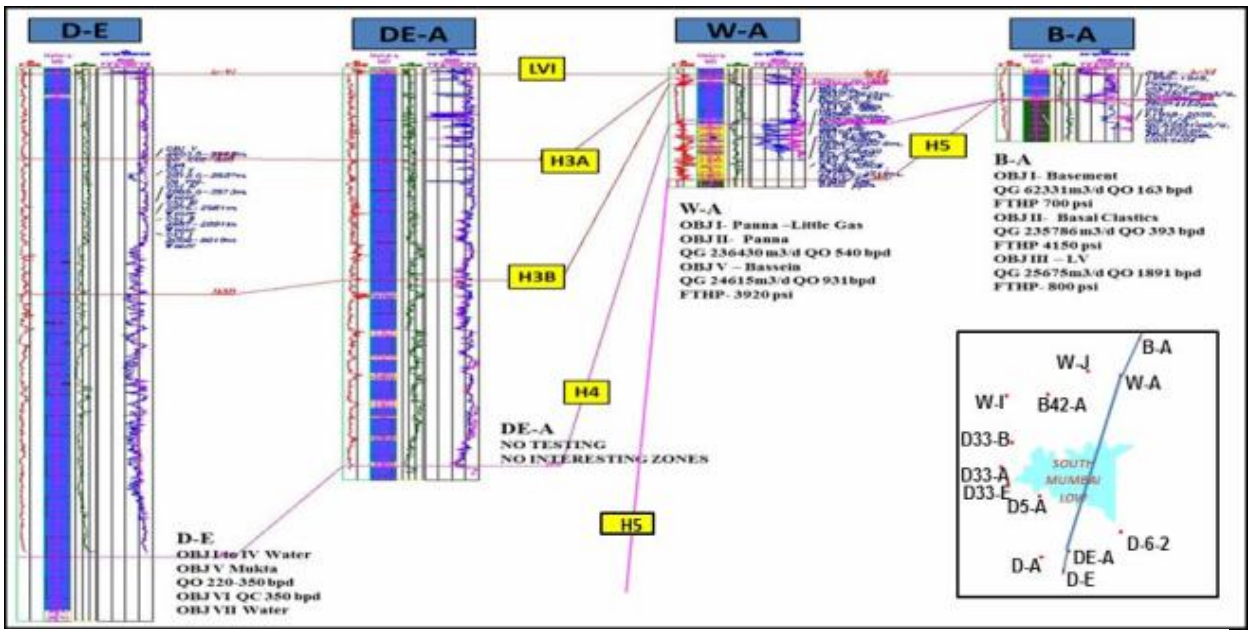

Figure 3: Correlation of wells from D18 to the southwest and WO/ B119 wells to the northeast across the South Mumbai Low

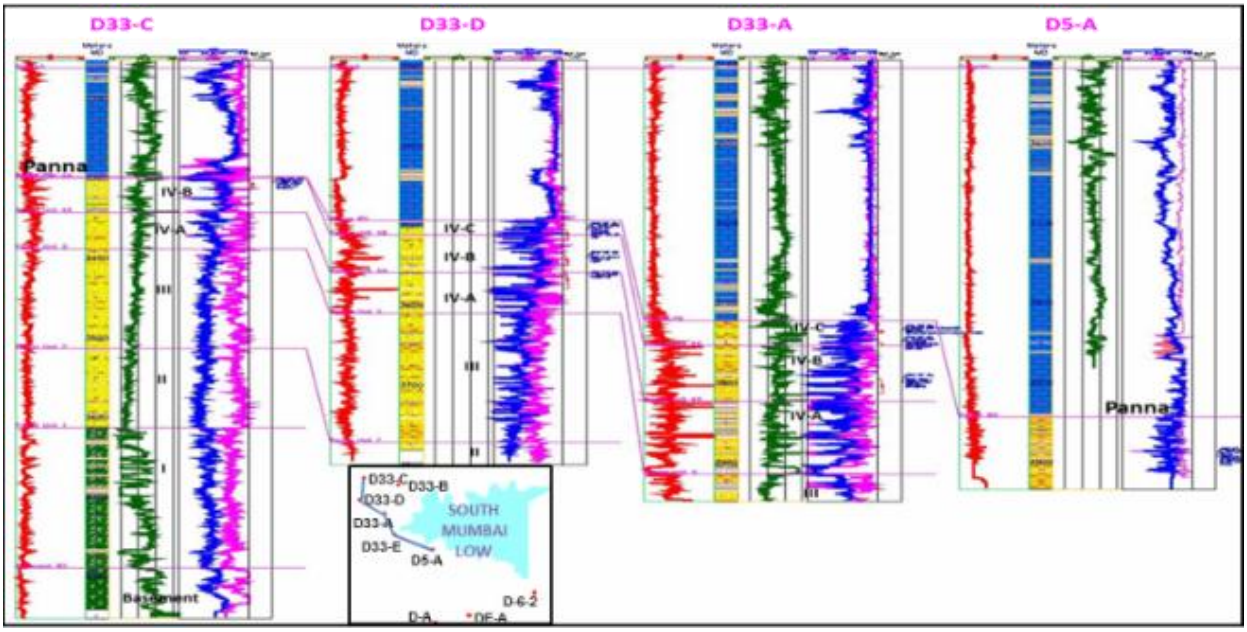

Figure 4: Map showing position of South Mumbai Low, Correlation line and Correlation of wells hung at H4 from D33 area on the western rising flank of the Low

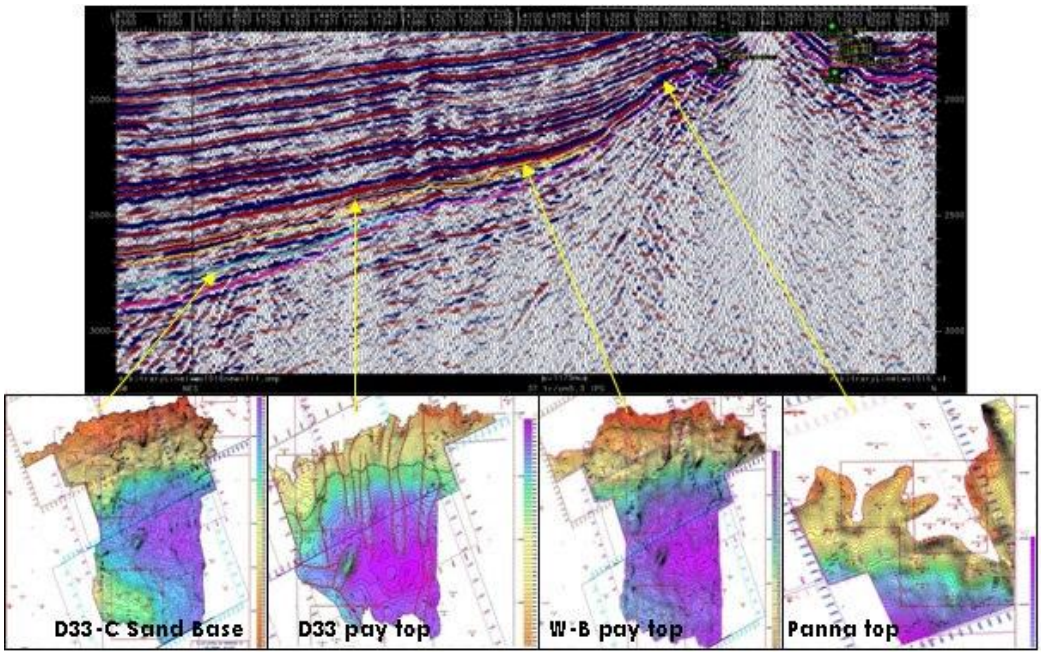

Figure 5: A Trace passing through WO wells towards the northern rising flank of the South Mumbai Low and the Time Structure Maps of the wedge-outs mapped

The well log correlations across the South Mumbai Low (figure 3) as well as on its western rising flank (figure 4) show the increasing Panna thickness towards the low.

The time structure maps of the horizons within Panna formation corresponding to the Panna Top, D33-A pay, the W-B pay and the sand base encountered in D33-C wells were prepared for the entire integrated area surrounding the South Mumbai Low. These maps give a clear indication that the younger and younger Panna sedimentation started further and further landwards, thus, forming the wedge-outs.

Structure & Stratigrapy

The original basement topography i.e. the Deccan Trap Top topography has played a crucial role in the deposition of the Panna clastics. The oldest sedimentation must have been the trap derivatives filling up the lowest parts of the South Mumbai Low. With transgression setting in more and more area must have got inundated and coarse clastics would have been deposited nearer to the shores and finer clastics got dispersed as plumes only to be deposited further away. Thus, it can be safely taken that the transgressional wedge-outs have a coarser texture near the paleo-shoreline and the texture goes on becoming finer and finer away from it. The areas with coarse and relatively less sorted sediments thus, form several rims along the rising flanks of the South Mumbai Low on all sides. But as the basement rise is relatively much more towards the Mumbai High side (northeastern side),it is probable that a larger number of well formed wedge-outs are seen towards the north and northeast, than towards the south.

The area has also witnessed smaller regressive phases which could have formed the pinch- outs on top of earlier deposited Panna clastics. The example of one such pinch-out is the D33-A pay which sits on earlier deposits and pinches out against the same rather than the basement (figure 6).

Panna Wedge-outs

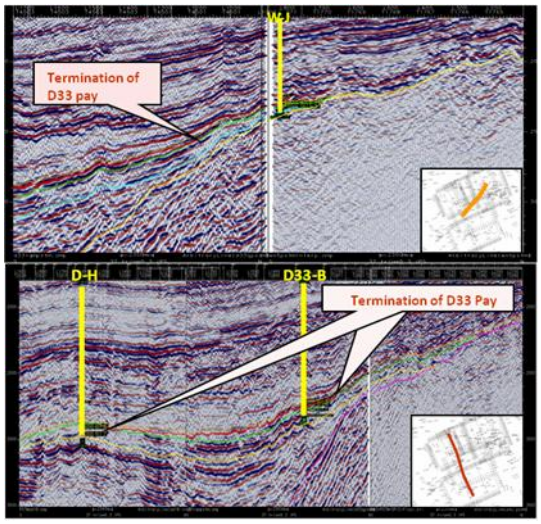

Figure 6: Arbitrary lines demonstrating the D33 pay pinching out on top of lower Panna layer instead of on the Basement.

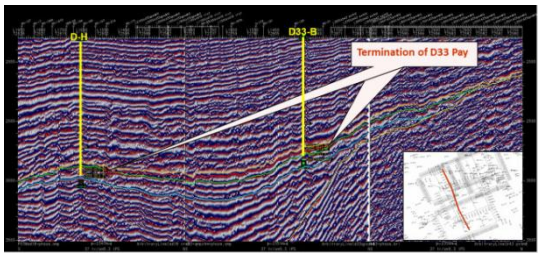

Figure 7: Arbitrary lines (Phase section) demonstrating the D33 pay pinching out on top of lower Panna layer instead of on the Basement

The isochronopach map between the top of D33 pay and the layer it is pinching out with shows the limits of its spatial distribution (figure 8) which are much lesser than that of the W-B pay pinching out on basement.

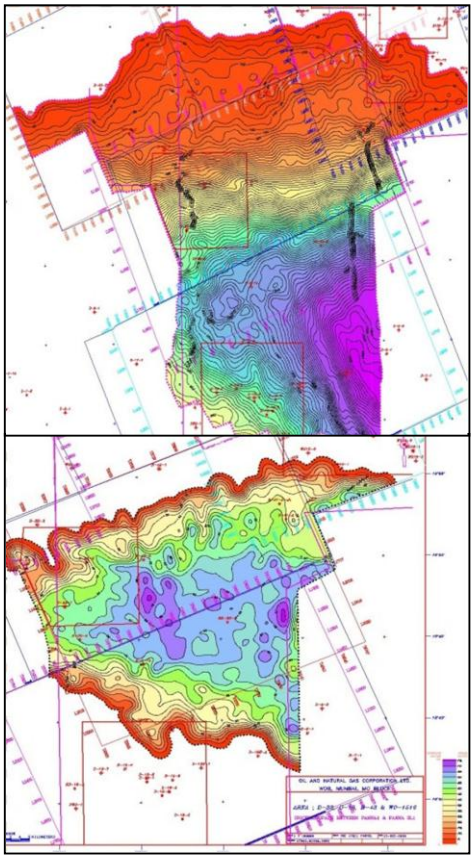

Figure 8: Isochronopach map between D33 pay and the lower correlated Panna layer and isochronopach map of W-B pay with Basement

Seismic attribute studies were carried out on all the seismic volumes involved in this study. Window based analysis was done using different time slots. Impedance, sweetness, RMS amplitude, unsupervised wavelet classification and spectral decomposition were the preferred attributes used. In D33 area stratal slicing was done for the Panna sequence and eight slices were made below Panna Top. The D33-A & B pay zone falls within the first two stratal slices. Similar seismic signature - low amplitude, low frequency patches are observed in the lower window of stratal slice 4 to stratal slice 6 towards the east of the main D33 field. The strata in this window wedges out against the basement much further to the east (not seen in the present 3D area). The comparison of RMS amplitudes of the younger Panna pay zone and the older window of slice 4 to slice 6 is seen in figure 9.

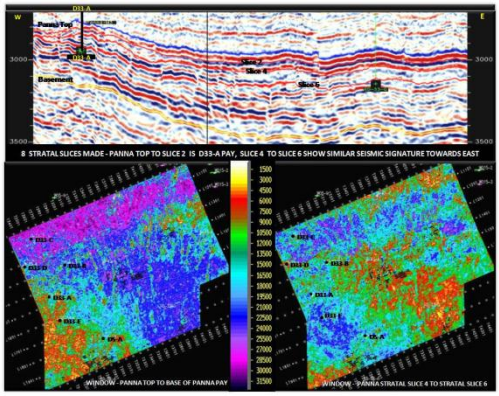

Figure 9: Comparison of RMS amplitude maps of two window slices in D33 area shows the similarity of amplitude response seen in the upper window near D33-A pay (Panna top to stratal slice 2) and the lower wedge-out window towards the east of D33-A area (Panna stratal slice 4 to stratal slice 6)

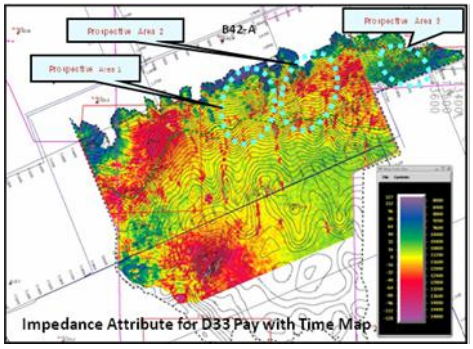

Figure 10: Impedance Attribute superimposed on Time structure map of D33 pay indicating the prospective areas

Three prospective areas (Prospect 1, Prospect 2 and Prospect 3) have been demarcated for the D33-A pay as shown on the impedance attribute map in figure 10 and further corroborated with the analysis of other attributes like sweetness (window- Panna Top to stratal slice 2), Spectral Decomposition (34 Hz.)and Unsupervised Wavelet Classification (figure 11).These areas fall within the LKO (last known oil) of the D33-A Pay horizon (pay encountered about 24 mts in two layers) and also show favorable parameters for most of the seismic attributes. Structurally the areas are falling on fault bound highs or on the rising flanks of the local intervening lows.

Two prospective areas have been demarcated for the W-B pay (Prospect 4 and Prospect 5 as seen in figure 12). Prospect 4 is a small localized area in the up dip of D33-C well, which was water bearing from the W-B pay equivalent, and falls within the LKO line of this pay. It has also got the structural advantage of being a fault bound closure. A very large area along the northern rising flank of the South Mumbai Low between the W-B pay horizon pinch-out line and the LKO line of the same pay is marked as Prospect 5. A number of small local fault bound highs can also be delineated within this zone, thus, making it quite prospective.

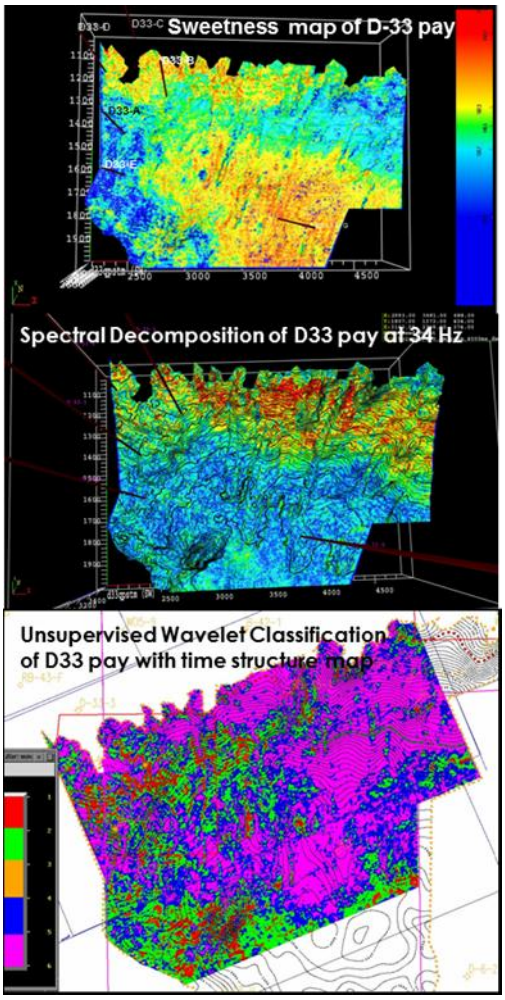

Figure 11: Sweetness, Spectral Decomposition at 34 Hz. and Unsupervised Wavelet Classification for the D33 pay

The same logic can be used to delineate the prospective locales for lower pinch-outs of the Panna sequence like the sand base within the D33-C well and others deeper down. This needs more analysis which is out of scope for this study.

Thus, a large area can be opened out for exploration for Panna clastics all around the South Mumbai Low by locating the pinch-out/ wedge-out areas which have a structural advantage.

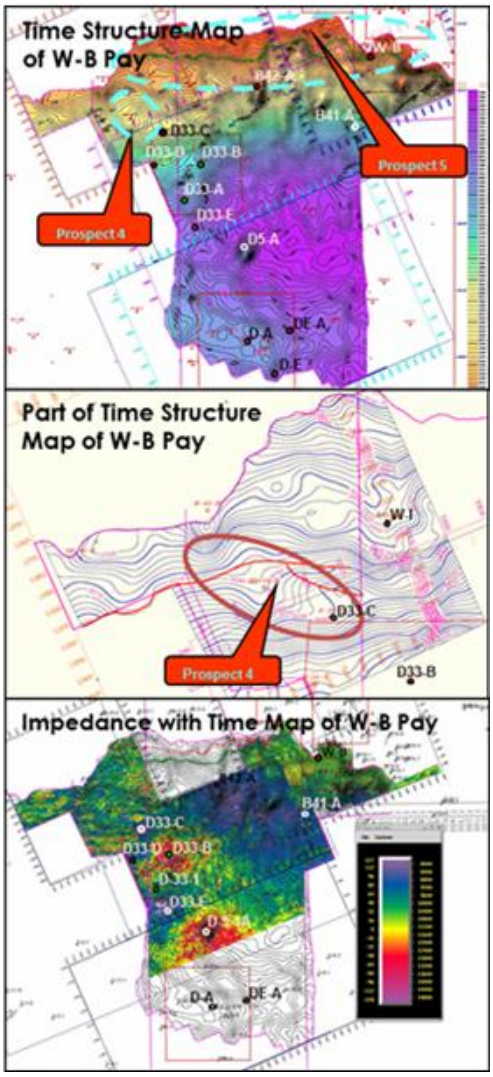

Figure 12: Time Map at W-B Pay with Prospective areas marked, Part of the same map (zoomed) with structural details of Prospect 4 and Impedance Attribute for W-B Pay

Conclusions

- The wedge-outs and pinch-outs in the Panna clastics on the flanks of the South Mumbai Low and especially if supported by good structural setup are likely potential hydrocarbon prospects.

- The seismic attribute studies like, inversion, sweetness, spectral decomposition and classification studies have helped to bring out the prospective locales at various stratigraphic levels within the Panna sequence.

- Five prospective locales have been identified – out of which three are prospective for D33 pay horizon and two are prospective for the W-B pay.

Acknowledgements

The authors are grateful to the Management of Oil and Natural Gas Corporation Ltd. For assigning this project, providing an opportunity to complete the project and giving permission to present this paper.