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Seismic Inversion : A Critical Aspect for Reservoir Characterisation

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Summary

Rudrasagar oil field in Assam & Assam Arakan Basin of India was discovered in 1960. The reservoir unit known Barail Main Sand (BMS) of Eocene to Oligocene is the pay sand in the field. An attempt has been made to understand the reservoir facies distribution over the field through seismic inversion study of the 3D seismic data in the area. The study has resulted in establishing relation between acoustic impedance and pay thickness. Seismic attributes generated from the acoustic impedance (AI) volume have also helped in understanding the facies distribution over the area.

Introduction

Assam & Assam Arakan Basin of north eastern part of India is known as petroliferous basin. Rudrasagar field is situated in the vicinity of Brahamputra arch and Disangmukh high and North of Kalugaon Low.

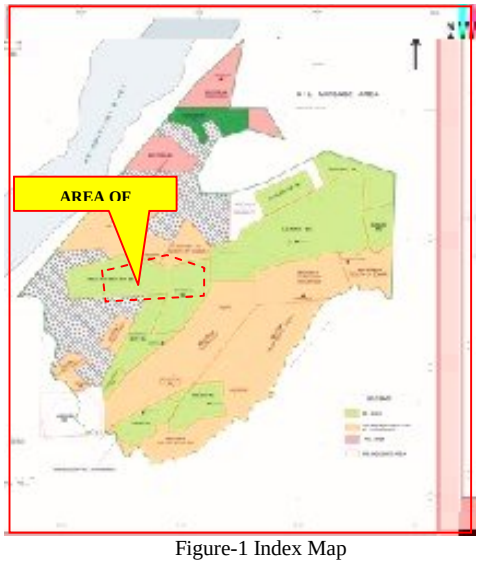

Figure-1 Index Map

Demulgaon and Charali field lie towards East and Southeast direction of the Rudrasagar Field (Fig.1). The field has a distinction of being the first ever oil field discovered by ONGC in the eastern region.

Structurally, Rudrasagar Field is a broad anticline with its longitudinal axis trending ENE- WSW direction. The field is bonded by a major fault with considerable displacement on the northern flank of the structure whereas towards southern and western part of structure ENE-WSW and NE-SW trending faults define its limit.

Hydrocarbon accumulation in the field is confined mostly to the uppermost part of arenaceous unit of Barail group sand, namely, BMS (Barail Main Sand) which is a prolific producer. BMS is mainly sandstone of Eocene to Oligocene age (Fig.2).

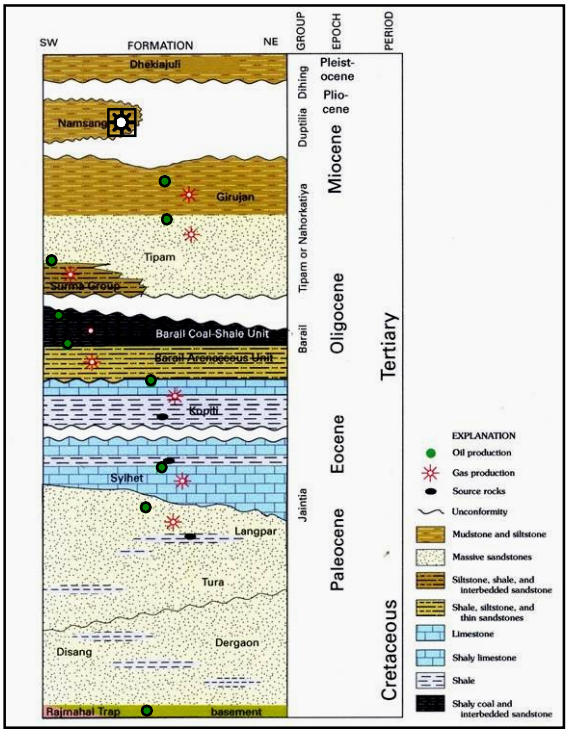

Figure-2 Generalized Stratigraphy of Assam Shelf

The Barail Main sand consists of thick sand unit with thin shale intercalations. The thickness of BMS unit in Rudrasagar structure varies between 150-180m and it is quite extensive except towards northwest where the facies gets deteriorated. The sands are medium to fine grained, sub angular to sub rounded, poorly consolidated and less compacted. The Log motif exhibits typical bell shape signature against the sand (Fig.3). The log motif indicates that the BMS is deposited in a lower deltaic distributary

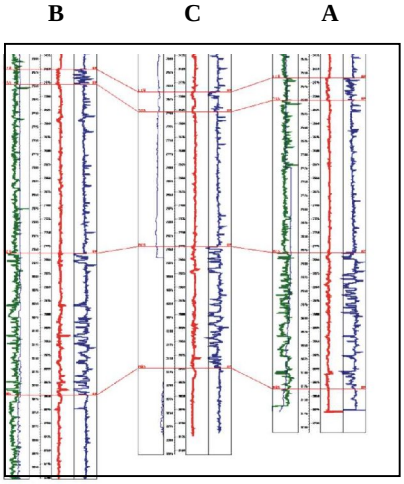

Figure-3 Log correlation of wells B, C and A

channel system though the total sand thickness is more than 150m. The hydrocarbon accumulation is confined to the upper part only.

The paper presents a detailed analysis of BMS reservoir unit through integrated study of 3D seismic and data from around 30 wells scattered all over the area.

Methodology

55 Sq km of 3D seismic data with bin size 25m x 50m and 30 fold over the Rudrasagar field has been used for study of seismic data.

Synthetic seismogram were generated for 25 wells for tie up of well and seismic data, by calibrating seismic events with well data using available VSP and check shot data. Overlay of synthetic seismogram of well B on inline 1280 with correlation of BMS unit is shown in Fig.- 4.

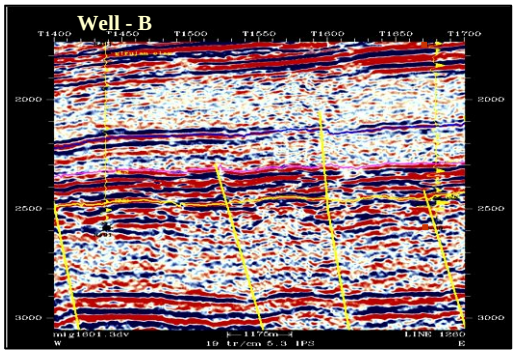

Figure-4 Synthetic Seismogram of well – B overlay on in line

The principal objective of seismic inversion is to transform seismic reflection data into a quantitative rock property for the description of the reservoir. Inverted volume of seismic data shows the lateral variation of the facies and helps the determination of reservoir unit.

The Hampson – Russel software was used to invert the seismic volume into Impedance volume. A few wells equally distributed in the area were taken for correlation of formation boundaries with seismic marker events.

Subsequently correlated wells have been taken up for the creating the initial model i.e velocity model and this velocity model was used to invert the seismic data. Band limited seismic inversion was carried out to generate seismic impedance volume. Average impedance time slices were generated from impedance volume corresponding to BMS sand units.

Seismic Attribute Studies:

Attribute Studies From Time Volume

With the same objective, a number of horizon and window based seismic amplitude attribute maps have been generated and studied. The seismic attribute used in the study with average absolute amplitude. Seismic attributes help to obtaining qualitative information about lithology distribution and also indicates stratigraphic features such as channels etc.

Average Absolute Amplitude from Time Volume

Different types of attributes such as Maximum trough amplitude, Maximum negative amplitude, Average amplitude, Maximum positive amplitude were observed to understand sand deposition and reservoir facies but these attributes do not suggest any trend. Finally average absolute amplitude study was taken up for seismic and in inverted data.

The study in time volume interprets in average absolute amplitude map generated for the pay sand of BMS in the interval -10 to 10ms , -10 to 20 , -10 to 30 and -10 to 40 with -10ms corresponding to datum and 10ms above of BMS unit. In general the attribute study in the above windows does not bring out any distinct pattern which could not be related to facies distribution or for pay thickness (Figs.5-8).

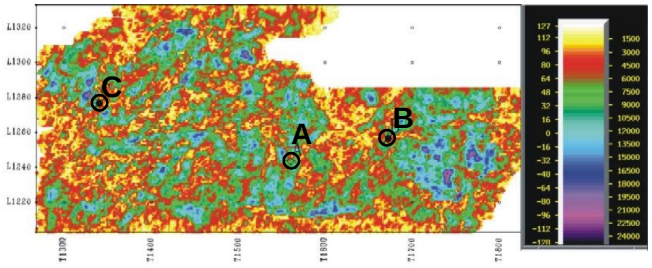

Figure-5 Average Absolute Amplitude -10 to +10 ms window at BMS

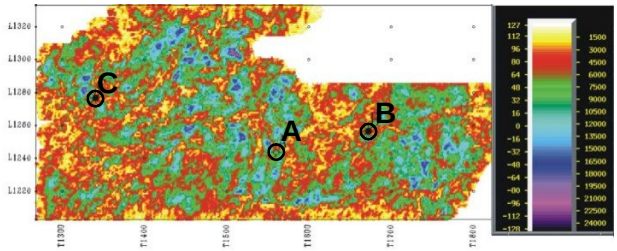

Figure-6 Average Absolute Amplitude -10 to +20 ms window at BMS

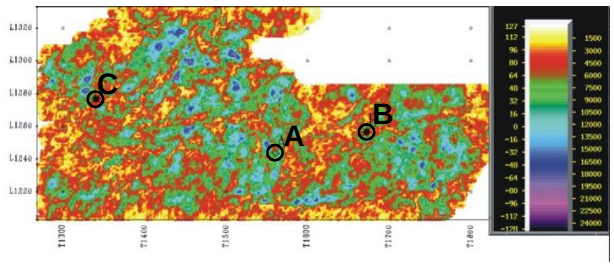

Figure-7 Average Absolute Amplitude -10 to +30 ms window at BMS

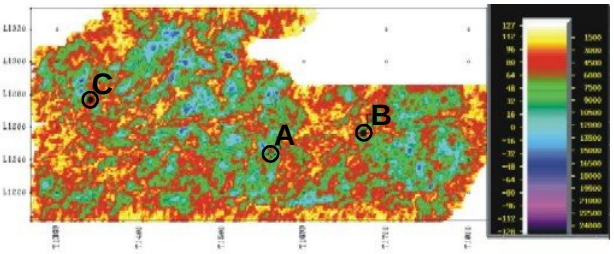

Figure-8 Average Absolute Amplitude -10 to +40 ms window at BMS

Average Absolute Amplitude Study from Inverted Seismic Volume

Average absolute amplitude map have been generated for the pay sand of BMS in the interval -10 to 10, -10 to 20 , -10 to 30 and -10 to 40 with -10 corresponding to (top of 10ms of BMS unit). In the study area pay thickness is ranging from 5m to 40m. Horizon based attribute were studied and it was found that once we go down from window -10 + 10 to 10 +30 ms the facies in the main field is developing continuously whereas in the window -10+40 and below the facies is start to deteriorate (Figs.9-12). When pay thickness is increasing it is giving good response in terms of facies whereas pay thickness is decreasing the quality of facies is also deteriorating. The acoustic Impedance range from 3000 to 8000 indicates good reservoir facies development. Maximum sand development known to be restricted in the main Rudrasagar field. This map indicates the variation in the facies and also distribution of sand bodies.

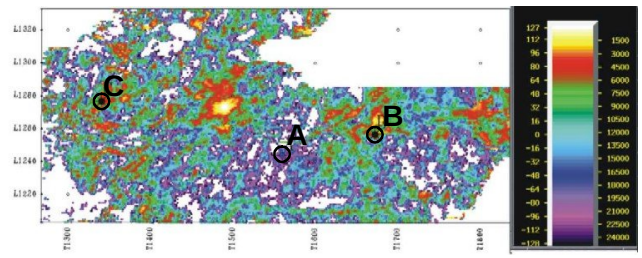

Figure-9 Average Absolute Amplitude -10 to +10 ms window at BMS (AI Volume)

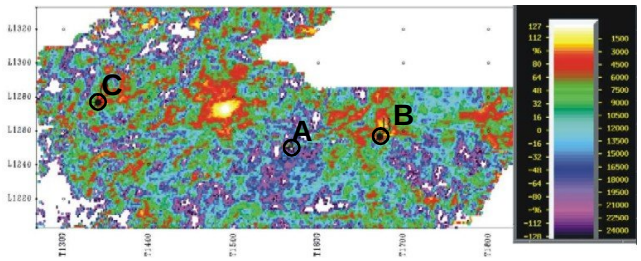

Figure-10 Average Absolute Amplitude -10 to +20 ms window at BMS (AI Volume)

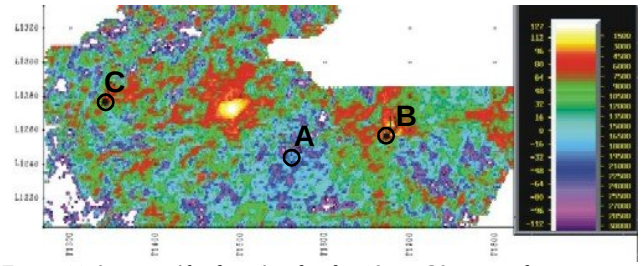

Figure-11 Average Absolute Amplitude -10 to +30 ms window at BMS (AI Volume)

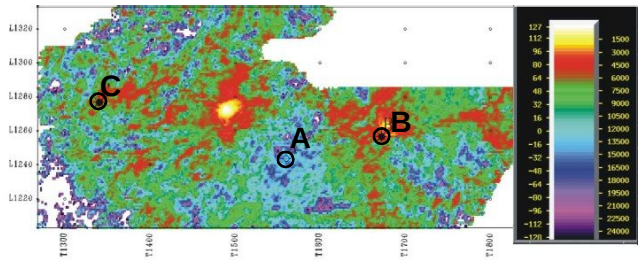

Figure-12 Average Absolute Amplitude -10 to +40 ms window at BMS (AI Volume)

Analysis & Findings

Well A was drilled upto 3200m and terminated within BMS unit. No interesting zones were encountered in BMS level it has not given any oil indication/ shows during drilling. It indicates that there is no development of good reservoir facies in well location.

Well B was drilled upto 3400m and it was perforated in the interval of 3221-25m below BMS and in initial testing it produced oil @ 46m3/d.

Well C was drilled upto 3327m within BMS unit and it was perforated just below BMS top in the interval of 3170-78m and it produced oil on self flow. The well has produced more than 55,000 tons so far and it is still producing.

After analyzing the data on time slices of impedance volume, it is found that producing wells are located in the area having same facies, whereas the well which is not producing having different facies.

Cross-plots & Analysis:

Cross plots were taken between AI and pay thickness to understand their relationship. It was observed that there are two distinct clustering of points in this field (Fig.13). for which the pay thickness varies from 5m to 40m whereas the acoustic impedance varies form 500-15000. The pay thickness was overlaid on acoustic impedance map (Fig.14), it was inferred that the better facies development where pay thickness is quite thick and they also following structural trend.

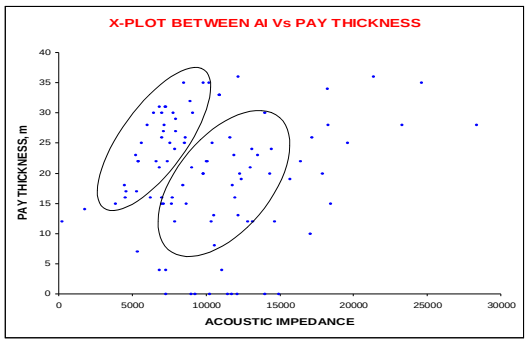

Figure-13 Cross Plot between Acoustic Impedance verses pay thickness

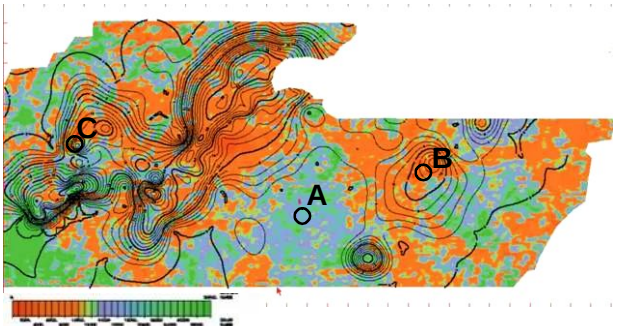

Figure-14 Pay Thickness of BMS Overlay on Impedance Volume

Conclusion

It is observed that it is possible to identify the poor and good facies on inverted seismic data which was not possible in normal seismic data volume.

It is observed that in the area of study pay thickness is also following structural trend.

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