Bengal Discovery: Its Seismic attribute Analysis

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Keywords

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Summary

Exploration of six decades in Bengal Basin resulted in a discovery of oil & gas in Mio-Pliocene sequence in a well in study area. Earlier findings were indication of hydrocarbons from different sequences viz. from basal Oligocene sand of Well-C and fractured Eocene limestone of well- K in the vicinity of Hinge zone area.

The current study focuses on integration of G&G data, to analyze the spatial and temporal distribution of reservoir sand associated with current discovery. Pay zone (gas and oil pay tops equivalent to Mio-Pliocene age) surfaces were mapped equivalent to hydrocarbon findings in well. Mixing of two channel systems has been established based on RMS amplitude, Sweetness and Amplitude Envelope attributes at gas pay level, indicator of stratigraphic entrapment for hydrocarbon. Impedance log/Impedance map shows lowering of impedance in Pay-zones. AVO analysis has also been carried out to characterize the gas sand which indicated class-IIP AVO anomaly. Post Stack Inversion shows that Impedance value for reservoir sands varies from 7900 to 8600 m/s*gm/cc.

Introduction

Bengal Basin is one of the major sedimentary basins of the Indian sub-continent, which falls in West Bengal of India and Bangladesh. Areal extent is around 90,700 km2, mostly covered with alluvium. This basin is demarcated by the Indian shield in the north and west and Surma basin in the east (Fig. 1). It is a divergent margin sedimentary basin rests over intracratonic Damodar graben and is occupied by the Permo-Triassic sediments of Gondwana super group and then overlain by Rajmahal traps. Thick successions of Late Cretaceous, Paleogene and Neogene sediments are deposited in the basin over Rajmahal Trap. Tectonically, the Bengal basin shows two stages of development, the rift phase and post trappean tectonic phase. During the initial phase, the basin has been subjected to extensional tectonics as a result of which horst and graben structural set up came into existence, where continental, fluvio-lacustrine, fluvio-esturaine and paralic sediments were deposited. Large amount of lava erupted through the crustal fractures accompanying the rifting and accumulated in grabenal lows.The major eruptive center was Rajmahal hills and the basaltic lavas have partially covered Gondwana sediments (ONGC. Unpublished report). After the lava flow activity, the basin was exposed to a passive margin tectonic set up as a result of which huge thickness of post trappeans sediments were deposited throughout the basin. The objective of the current study is to chase the finding of hydrocarbon within Mio-Pliocene sand along the hinge zone in Bengal basin. Prospectivity in and around hinge zone in the south east of Well-K area has been conceptualized and seismic attributes were analysed to understand the nature of sand and its extension.

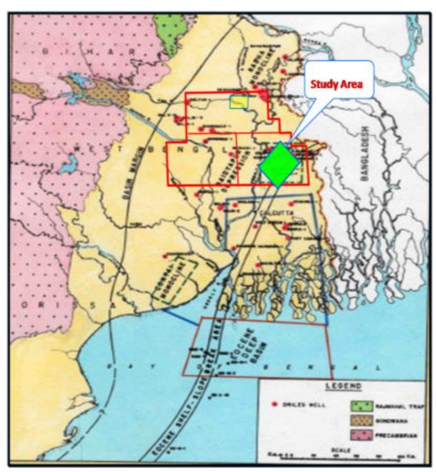

Fig.1: Location map of the study area with Indian Shield and Surma Basin, Bangladesh (ONGC unpublished report)

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Geology and Stratigraphy

The geology and tectonics of the basin are well documented and discussed by many authors including Biswas (1961), Roy Barman (1983) Alam et al. (2003) and Mukherjee et al. (2009). Tectonically, the Bengal Basin indicates three stages of development. (1) The rift stage, forming intra-cratonic rift basin, hosting Pre-trappean Gondwana sediments. (2) The Rift-Drift transition stage marked by development of a series of hot spots characterized by effusion of Rajmahal volcanics. (3) The Drift Stage from Late Cretaceous onwards marks evolution of the basin from marginal sag into a pericratonic one.

The Bengal basin is traditionally subdivided into four NE-SW trending tectonic zones. These zones from west to east are as follows: (a) Basin Margin zone: Characterized by shallow depth of Proterozoic rocks with down to basement en-echelon fault system. (b) Shelf zone: Where Proterozoic basement maintains a uniform low gradient towards east and south east. (c) Hinge zone: Characterized by sudden increase in the slope, this is distinct at the level of Eocene limestone top. (d) Deep Basin: Where basement is not identifiable in available seismic section up to a depth of 6 sec. Generalised stratigraphy shows the lithological variations (Fig. 2).

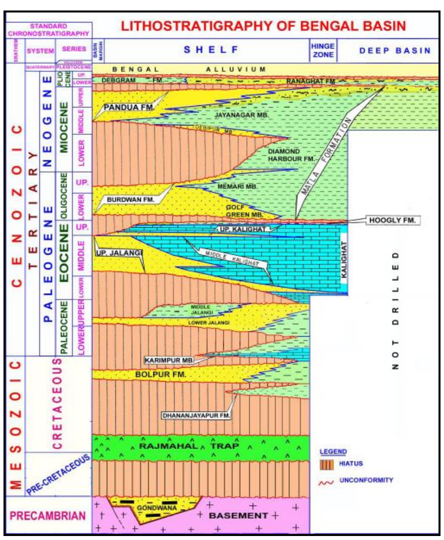

Fig. 2: Generalised stratigraphy of Bengal Basin (Chandra M., 1993)

Methodology

The current analysis has been done on PSTM merge volume of different seismic campaign covering an area of 900 SKM (Fig. 3). Pay equivalent sands are mapped in study area and different seismic attribute analysis (RMS amplitude (Gas pay sand 10ms window), Amplitude envelope (Gas pay sand 10ms window), Sweetness and Spectral decomposition (Gas pay sand 20ms window)) have been carried out to see the pay sand response.

Impedance is a key parameter for the characterization of HC bearing sand. The post stack inversion study was carried out for generation of P-impedance volume. Input data for the study were 3D post- stack seismic data, conditioned elastic logs (P-sonic and Density) of seven drilled wells in the hinge zone area. A composite wavelet was extracted using the seismic and wells. This composite wavelet was used in the inversion process. Seismic to synthetic correlation was carried out for 7 wells situated in the seismic volume. Synthetic seismograms of these wells with correlation coefficient more than 80% were used. Low frequency P-impedance model was built and model based inversion was carried out after selecting most suited inversion parameters to generate P-impedance volume for 1500ms to 2400ms. Quality check of inversion result was done by comparing inverted P-impedance and well P-impedance. For better understanding of low to medium impedance sand, Gamma vs P-impedance and P-impedance vs Vp/Vs cross plots were also prepared.

AVO modelling along the well gives a quick analysis of amplitude response with offset along the gas-pay zone. Elastic modeling (Elastic synthetic seismogram) is carried out using Density, P-wave and S-wave velocity recorded in the well. Seismic to well tie shows both the pay tops (oil & gas) is representing by trough (Fig.6a). Amplitude vs offset plot has been prepared to see the AVO response of gas- pay sand.

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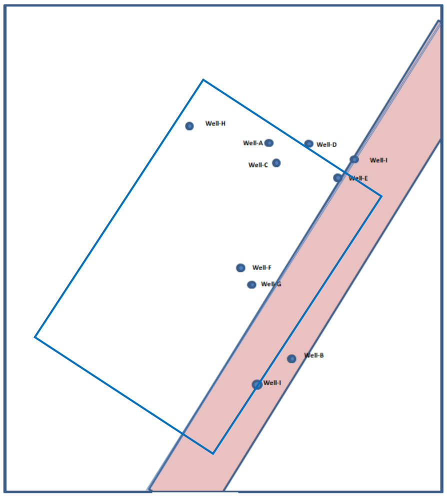

Fig. 3: Seismic campaign with NELP boundary and drilled wells in the study area

Result and Discussion

Seismic attributes helped in determining the presence of two channel geometry within the Mio-Piocene sequences. These fluvial channel were deposited by deep incision of fluvial channels in shelf environment. Envelope attribute shows a mixing of two channel system in the area provides a stratigraphic entrapment condition (Fig. 4). Low impedance has been observed within the zone of interest .Gas zone and Oil zone reservoirs in well-B of study area shows the P Impedance of the range 7800 to 8600m/s*gm/cc. The same has been used to infer sand distribution in space and time (Fig. 5).
AVO study along the well shows increase of amplitude with offset in gas zone. Gradient Vs intercept crossplot shows the class-II AVO (Fig 6b & 6c). A cross-plot between Gamma-log and Impedance log shows that fluid can be characterized upto some extent in case of gas pay which is silty in nature however, in case of oil pay, the reservoir is gritty-sandy in nature show a little mixing with water bearing sands (Fig. 7). The P-impedance vs Vp/Vs plot shows that the gas pay has low Vp/Vs and low impedance while oil pay falls in two cluster (1) Low Vp/Vs and low impedance (2) Low Vp/Vs and high impedance (Fig. 8). This plot suggests the presence of two separate lithofacies associated with the reservoir zone. Additionally, thick shale (~250m) layer above the oil pay top provides a good entrapment. The acoustic impedance and gamma log shows that the sands above the shale layer are showing lower acoustic impedance and characterized by high amplitude in seismic while the sand below the shale falls into higher Acoustic impedance. The shale pack in seismic can be characterized by transparent reflection in seismic.

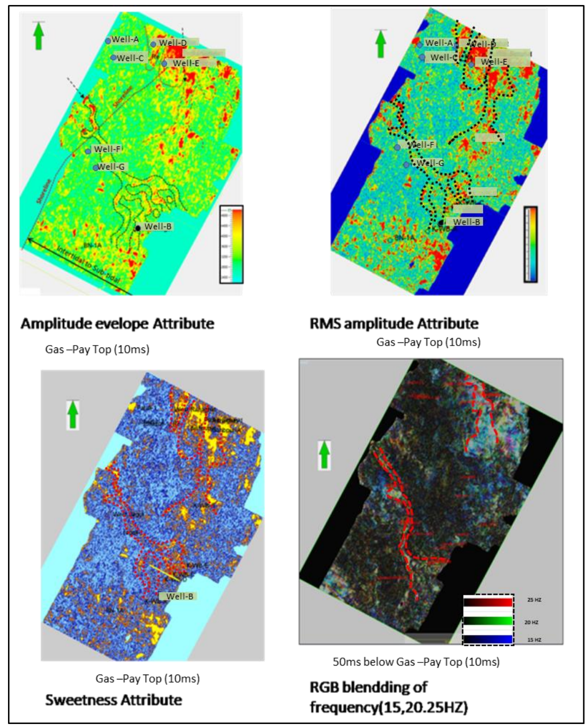

Fig. 4: Different attribute response representing the channel Juxtaposition

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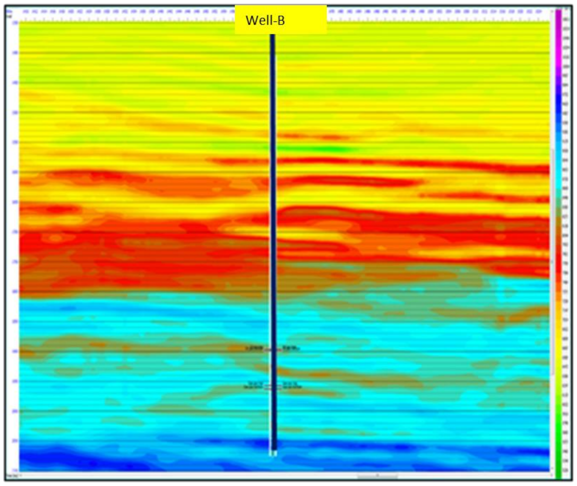

Fig. 5: P-impedance response of pay sands (a) Vertical section

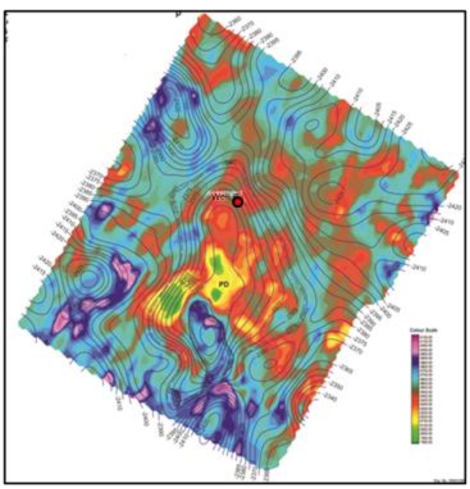

Fig. 5: P-impedance response of pay sands (b) spatial distribution

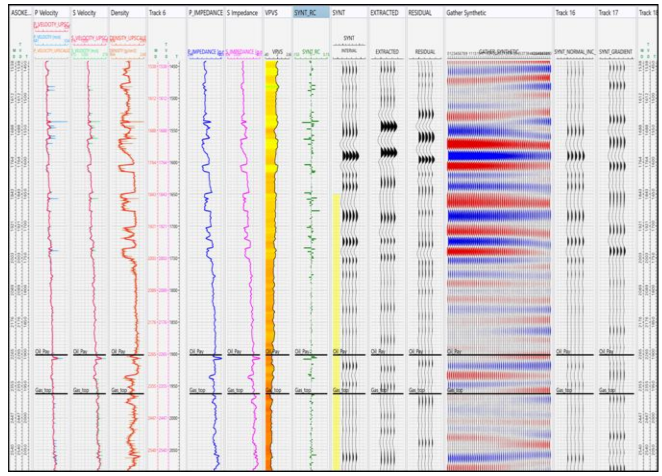

Fig. 6a: Synthetic Seismogram through well B

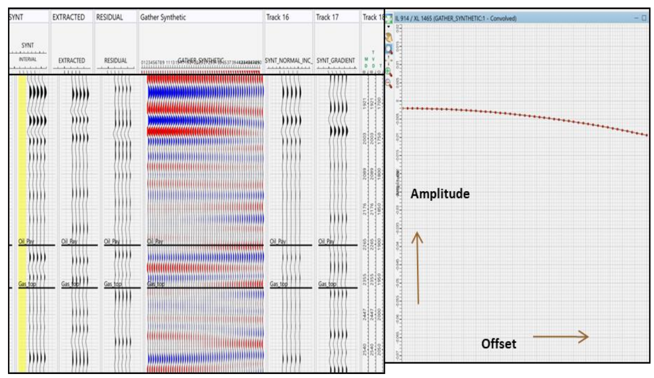

Fig. 6b: Amplitude Vs Offset along the gas-pay sand

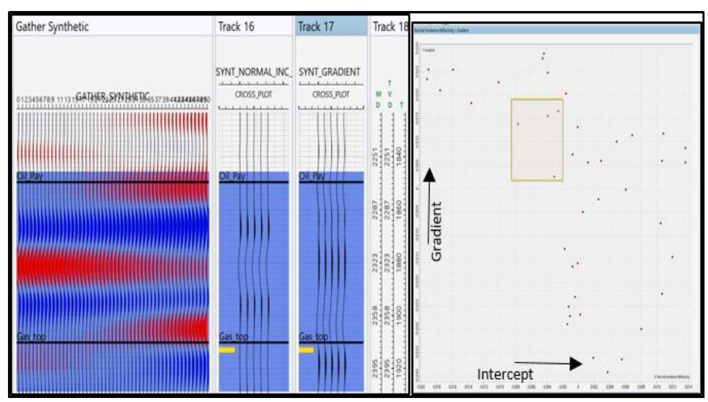

Fig. 6c: Gradient vs Intercept

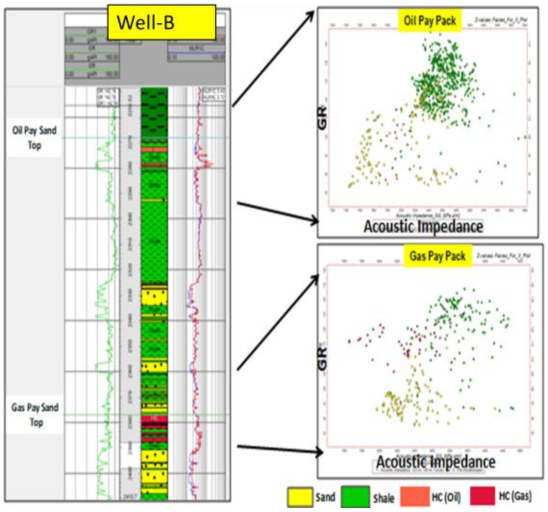

Fig. 7: Cross Plot between Gamma Vs Acoustic Impedance

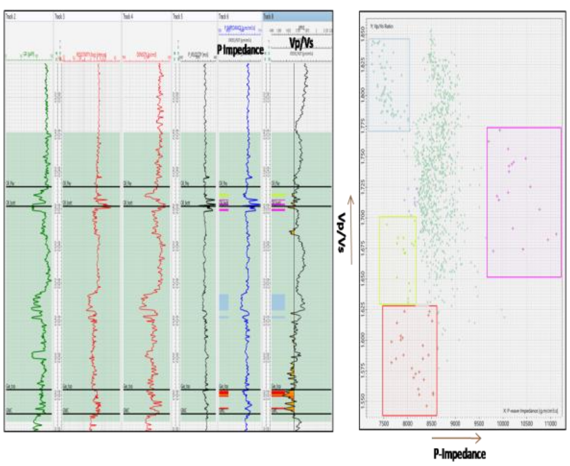

Fig. 8: P-impedance vs Vp/Vs plot of characterize oil pay sand and gas pay sand

Conclusions

The area around the Well-B is characterised by strati-structural plays, the pay sand has channel geometry and the gas finding is at the interference of two channel systems. Low impedance anomaly has been observed along the pay sand and spatially developed in around the well. AVO analysis shows class–IIP AVO anomaly in pay sand. The interbedding shale layers in the pay zones show high impedance. A thick layer of high impedance has been seen above the pay, is probably the cap rock for the reservoirs.

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