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Anisotropic Depth Imaging of Heera Panna Bassein
– An interpretive case study

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Summary

A significant variation within the Miocene sequences was observed in the producing wells in the southern Heera- Panna-Bassein block of Mumbai Offshore Basin. An area of approximately 890 sq. km was identified for velocity modelling and depth imaging. The area is having maximum occurrences of patchy carbonates, amplitude anomalies, velocity anomalies and pseudo structures. Migration algorithms dealing with imaging are not able to handle the depth conversion issues accurately. Imaging becomes more challenging when high density and high velocity formations are present.

It has been shown that anisotropic PSDM (APSDM) outputs are better positioned than conventional depth imaging outputs. APSDM incorporates accurate imaging as well as depth positioning. The methodology to incorporate anisotropy (Thomson, 1986) has been illustrated by taking examples from Mumbai offshore area. Integrated analysis of 3D seismic data, well logs, well markers and VSP data including geological inputs has been carried out to understand the depositional framework.

***Keywords**: Thomson's Parameters (Epsilon and delta)*

Introduction

The area of study is located in the southern Heera-Panna-Bassein (HPB) block of Mumbai Offshore Basin (Fig. 1). This block, positioned in the east of Mumbai High/Platform and south of Surat Depression, has three distinct N-S to NW-SE trending tectonic units which lose their identity in Miocene. The western block is a composite high block dissected by a number of small grabens. The Central graben is a syn sedimentary sink during Paleogene and Early Neogene. The eastern block is a gentle eastward rising homocline.

The facies distribution and the depositional setting of the Miocene carbonates in the HPB area indicates development of carbonate facies in structurally higher area and alternations of carbonate/shale in the lows and graben area (Mishra et al, 2011).

Objective of the study

This study was aimed to map actual velocity variation associated with relatively thin and patchy Miocene carbonates (Fig. 2).

Miocene Carbonates, occurring in patches affect the structural disposition and reflection responses of deeper levels. It has been found that these sporadic depositions lead to the incorrect depth values. The Miocene carbonates are having higher velocities than enclosing shale. Because of lateral and temporal variation in velocities at shallower levels, pseudo structures are created at deeper levels. As a result the success ratio decreases for the placement of production wells within the reservoir.

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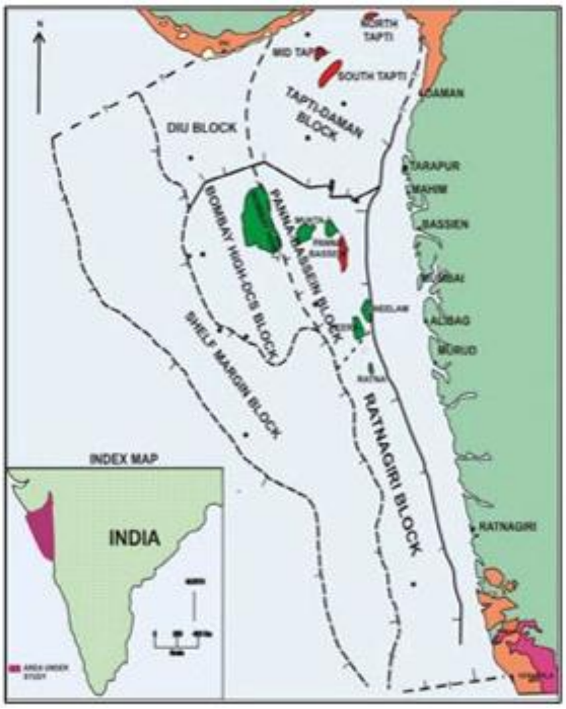


Fig. 1: Tectonic map of Western Mumbai Offshore Basin (after Pandey et al., 1998).

The study area is characterized by massive shale (Backus, 1962) around 800-1000m underlain by thick limestone - shale alternations. The anisotropic behaviour of shale is well established. Thus, an anisotropic approach was utilized to evolve a reliable depth image, high resolution velocity volume and to address depth conversion issues in the southern HPB block.

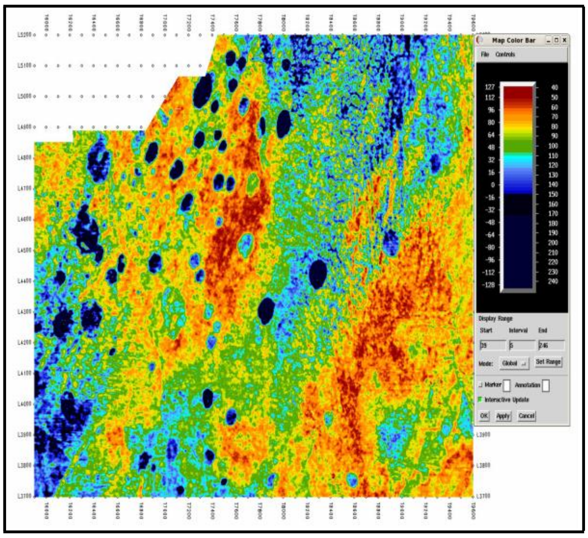


Fig. 2: RMS amplitude map where dark blue patches indicate sporadic depositions of high density high velocity Miocene carbonates.

Analytical Framework

Most of the crustal rocks are anisotropic in nature. This is mainly due to fracturing, layering and complex crystal structure of rocks Imaging addresses the proper focusing and lateral positioning of reflectors, but does not result in a true depth data set, even if depth migration is used (Al-Chalabi,1994; Schultz,1999).Even in totally isotropic media, therefore, unless well data are incorporated into the velocity model (Alkhalifah & Tsvankin, 1995), there will probably be misties - especially due to the tendency of picking towards higher side to discriminate against multiples.

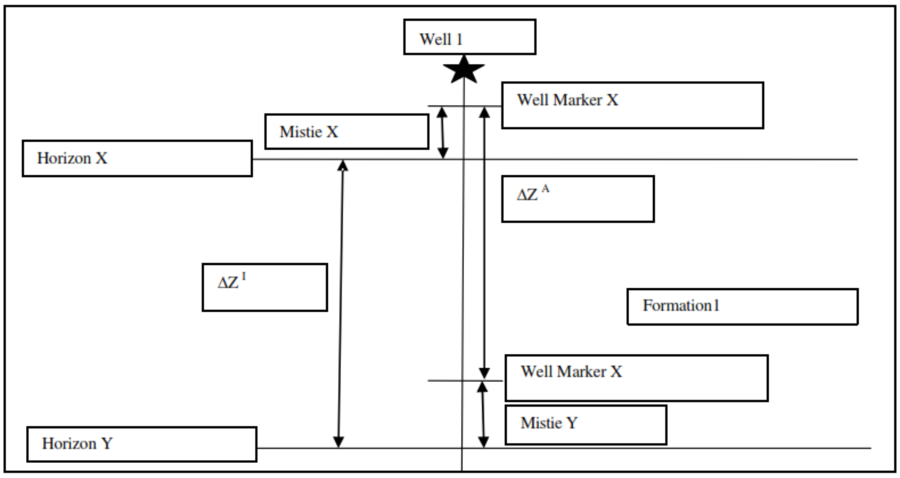


Fig. 3: Definition of Anisotropic Parameters

Estimation of Anisotropic Parameters (δ, ε, V_{0a})

The anisotropic parameters include anisotropic interval velocity, Epsilon and Delta which are Thomson's Parameters (Thomson, 1986). For the estimation of delta, picked time migrated (TM) Maps along dominant reflectors are scaled to depth maps.

The delta (δ) is calculated according to the following relationship (Tsvankin, 2001):

$$\delta = \tfrac{1}{2}\,[\{\Delta Z^{I} / \Delta Z^{A}\}^{2} - 1]$$

where ΔZ^{I} is isotropy layer thickness (measured from the structural model or from the top horizon map to bottom) which is

ΔZ^{I} (Formation1) = Formation1 bottom -Formation1 top

and ΔZ^{A} is anisotropy layer thickness (measured from the well time - depth pairs log between T1 and T2 or top horizon marker to bottom).(Fig. 3)

Epsilon can be derived from Eta analysis for far offsets but small inaccuracy in Eta may lead to a big inaccuracy in Epsilon. Thus, as a guess value we can begin with setting, δ(delta) equivalent to ε (Epsilon).

$$\delta = \varepsilon$$

The isotropic Interval Velocity (V_0) is scaled with delta volume to create Anisotropic Interval Velocity (V_{0a}) based on following relation ((Tsvankin, 2001)):

$$V_{0a} = V_0 / (1+2\delta)^{1/2}$$

Application

The APSDM method described above has been applied to 3D seismic reflection offshore data. The target zone under study is a reservoir located in Heera-Panna-Bassein block of Mumbai Offshore Basin.

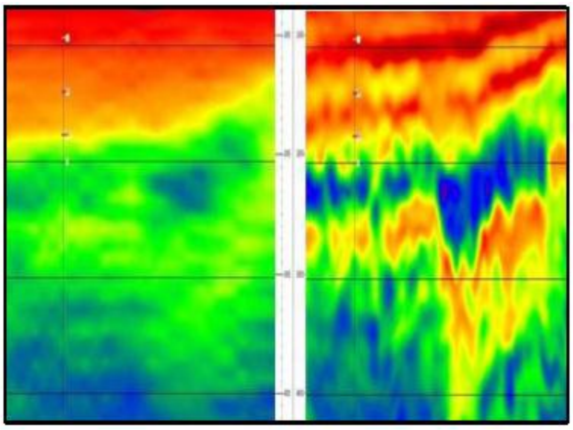
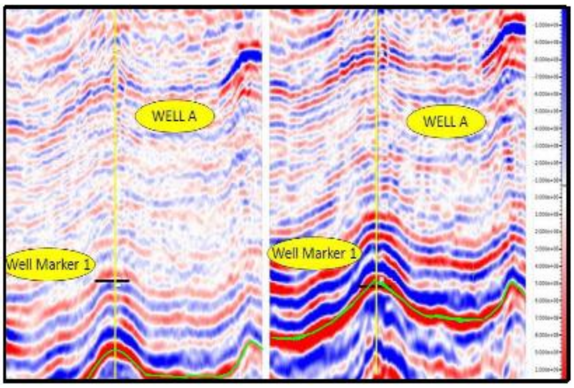


Fig. 4: Isotropic interval velocity volume v/s anisotropic interval velocity volume.

After incorporation of anisotropic parameters a better interval velocity volume was obtained (Fig 4).The velocity variation due to presence of Miocene carbonates is clearly visible in the volume. APSDM was executed taking the estimated anisotropic parameters as input. Subsequently the depth section shows much improved match with the well tops (Fig 5, Fig.6, Fig 7).



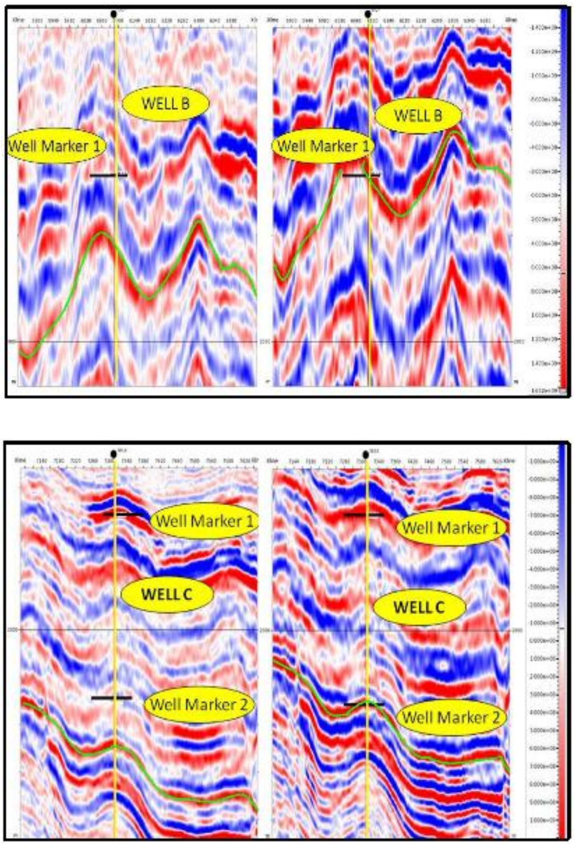


Fig. 7: Isotropic depth section v/s anisotropic depth section passing through Well A, B and C.

The QC of interval velocity has been provided in Fig 8.The flat gathers and improved image validates the accuracy of anisotropic interval velocity volume over isotropic interval velocity volume.

Moreover the compatibility of Sonic Log with the anisotropic interval velocity model validates the same (Fig9).Fig. 10 shows the flowchart to estimate the values of anisotropic parameters using Anisotropic Pre stack depth migration.

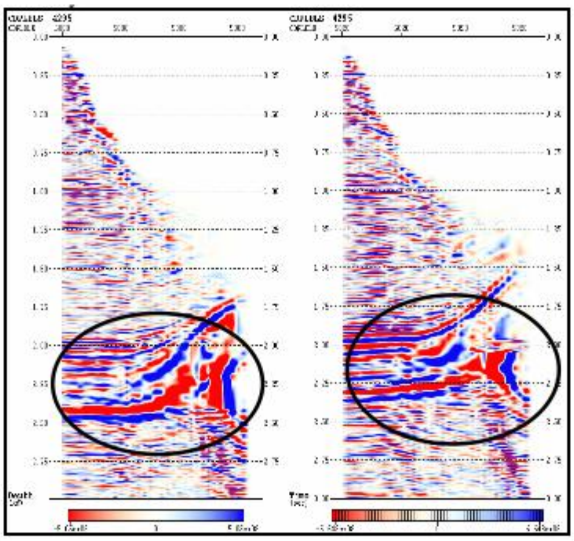


Fig. 8: The gather flatness displaying the QC of isotropic interval velocity volume v/s anisotropic interval velocity volume.

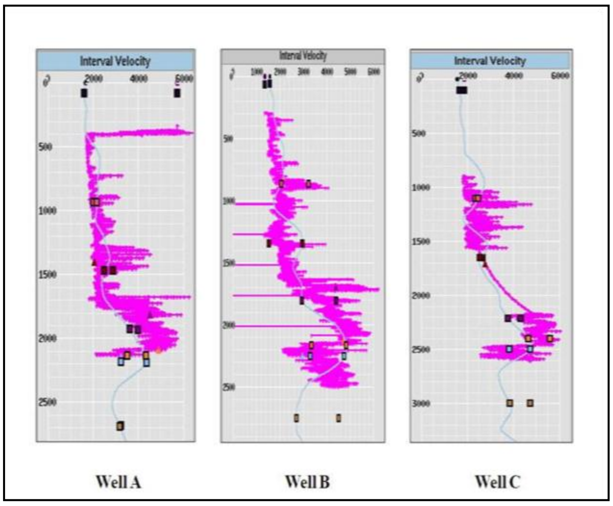


Fig. 9: Compatibility of Sonic Log (Pink color) with the updated interval velocity (Blue color)

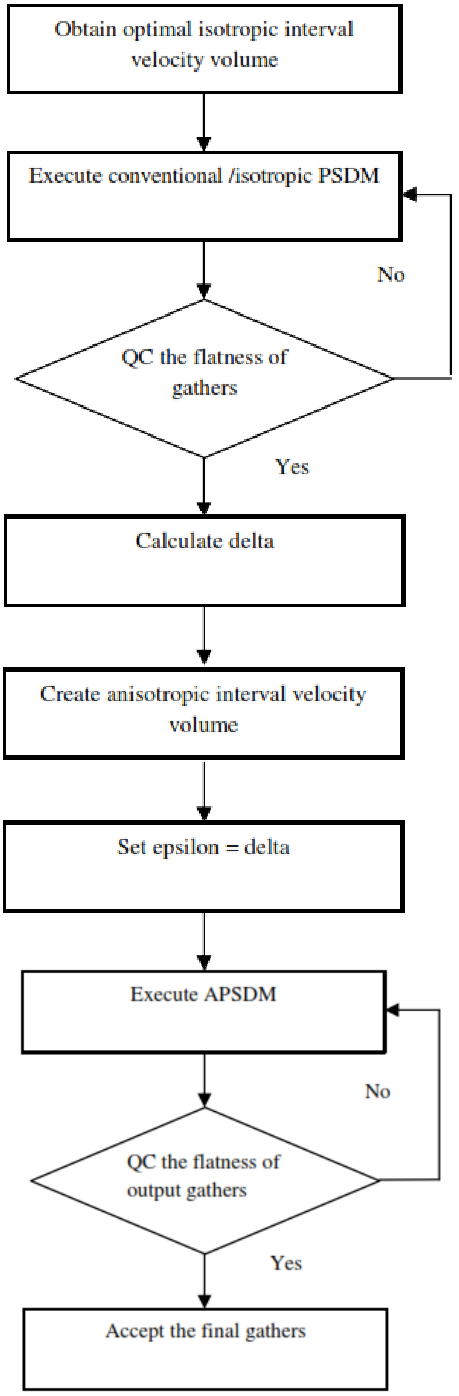


Fig. 10: A flow chart showing the workflow of APSDM.

Conclusion

The utility of true depth imaging using Anisotropic Approach has been demonstrated in the present study. It has been found that data from most of the wells are in agreement with well markers at major horizons. The ratio of success in well matching is quite high. Thus the deliverables including anisotropic velocity volume and PSDM gathers are highly amiable for structural modeling, inversion and attribute analysis.

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