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Innovative approach of velocity correction for shallow carbonates in Regional mapping and hydrocarbon entrapment analysis: Case study from Mumbai Offshore Basin, India

Abstract

Mumbai Offshore Basin, a pericratonic basin on the western continental shelf of India, exhibits a typical Passive Margin basin architecture and it harbours prolific volumes of oil and gas in the Tertiary carbonate and clastic reservoirs. Basin is genetically divided into six tectonic blocks viz, Tapti-Daman, Diu, Heera-Panna-Bassein, Mumbai high-Deep Continental Shelf (DCS), Ratnagiri, and Shelf Margin exhibiting different tectono-sedimentary assemblages.

Sedimentary basin fill comprises of three mega tertiary depositional cycles, the oldest being Late Paleocene-Early Eocene, comprising mostly shales and minor sands, was deposited in restricted shelf, paralic and continental environments in fast subsiding Tapti-Daman area and in the well-marked N-S trending grabens along the central part of Heera-Bassein and Ratnagiri blocks. The second clastic cycle of Late Oligocene-Middle Miocene age is well developed in the main depocentres of Shelf Margin and Saurashtra basin, although considerable thickness exists over the platform areas. The last phase of clastic sedimentation of Middle/Late Miocene-Holocene age covered the entire basin representing the latest transgressive drowning.

Two major shallow shelf platform carbonate cycles are embedded in the stratigraphic column, namely the Middle Eocene to Early Oligocene cycle covering the entire platform area except Bombay High and its immediate neighbourhood. The second carbonate phase during Late Oligocene to Middle Miocene covered Bombay High and surrounding periphery. Owing to high clastic influx, the resultant area under carbonate deposition oscillated in vertico-temporal dimensions and eventually the platform was drowned under transgressive sea level rise and increased clastic influx by late Middle Miocene.

Interplay of Multi cyclic carbonate & clastic sedimentation processes over shallow shelf area and concurrent structural changes has resulted in to genetically complex and laterally varying structural fabric in the basin. Besides structural mapping of reservoirs and genetic correlation of faults and associated structural / strati-structural traps, facies mapping in carbonates and clastics along with structural inversion and strike-slip movements with chronological relationship with migration and accumulation processes form the critical elements for successful exploration and production program in the basin. However, in spite of adopting fairly robust workflows on these lines, several drilling surprises and hydrodynamic anomalies are reported in the major part of the basin.

Continued exploration with extensive 3D seismic coverage and drilling in the basin have revealed that relative sea level changes during Oligo-Miocene has created oscillating carbonate tongues of varying thickness and lateral extent over major part of the basin, which differentially alter the structural fabric at reservoir levels and it is quite challenging to mitigate the impact using conventional G&G workflows.

This paper describes a case study from the basin with an innovative workflow adopted for correction of such shallow velocity anomalies caused due to isolated carbonate bodies above the formation of interest. Isolated carbonate bodies were identified on a regional scale using various seismic attributes. Interval velocities in shallow layers were modified locally and layer-by-layer, based on the presence of high amplitudes corresponding to carbonates. Thus, the corrected interval velocities were utilised for generating structure maps which are devoid of any pseudo-highs and more representative of the subsurface. This study led to the significantly improved structural mapping of the Panna-Mukta and Bassein reservoir geometries and validation of hydrodynamic fluid distribution in reservoirs, which eventually improved the exploratory success in the basin. Geometrically corrected Post-stack seismic structural & texture attributes better elucidate the structural geometries, nature of structural discontinuities, changing Paleo-depositional setup and vertical - lateral facies changes that helped in implementing the successful exploration program in the basin. Adopted workflow will be useful in other basins, where laterally changing shallow occurring velocity anomalies impact the reservoir level geometries and complicate hydrodynamic fluid distribution trends.