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Tidally influenced thin channel geometry mapping using pixel-based attribute: A case study from Tapti Daman Sector, Western Offshore Basin, India

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Abstract

Tapti Daman sector located in Northern part of Western Offshore Basin, comprises various gas bearing structures like B-12/C-26, C-2, C-23, C-24, C-39 and NTP etc. It represents transitional environment from clastics dominated Cambay Basin in NE to carbonate dominated Mumbai Offshore in SW. Daman Formation of Late Oligocene has witnessed clastics input in Tapti Daman Sector. Daman Formation sands are deposited under tidally influenced channel bar system. Multi-stack sands of Daman Formation are primarily gas bearing and characterized by reservoir properties such as sand thickness, grain size and porosities. Mapping of these sands remain challenge as it goes beyond the seismic temporal resolution, also it has similar attribute response for gas filled sands and brine sands with good porosity. Frequency or amplitude-based attributes are mostly used for extraction of geological information from seismic data. Mostly used method for seismic attribute extraction is window based, that sometime unable to capture the geological information embedded in seismic data due to averaging of the properties. Therefore, characterization of geologically complex setup tidal channel bar system requires multi attributes information altogether without average the properties. A new technology adopted to overcome the problem is pixel-based attribute characterization which provide sharpened RGB volume with color range. The combination of SRGB volumes provide better structural and geological information for interpretation and analysis. In this study, this approach is adopted to decipher the thin multi-stack channel geomorphology of Daman Formation in C-24 field of Tapti Daman sector.

Introduction

Reservoir characterization and channel geomorphology delineation in tidally influenced deltaic multi-stack channel/bar systems are perpetual modeling challenge. This becomes more challenging when variable thickness of the sand over the space embedded in the shale remain undetected in seismic as they fall beyond the seismic resolution. Moreover, the complex deltaic channel/bar system show high degree of change in geomorphological feature like channels, bars and tidal flat etc. Interpretation of Electro logs provide vertical information at a point, whereas spatial extent is possible through interpretation of 3D seismic data. Seismic information like amplitude and frequency are highly dependent on petrophysical properties of clastics such as grain size, sorting composition etc. Traditionally wavelet-based signal processing required analysis of window more than 5 samples length for signal improvement, also window-based attributes average the seismic properties. In this paper pixel-based approach is adopted to decipher the sand geometry. This technique has vertical resolution of 1-2 samples length and enable attribute response pixel to pixel without averaging the property.

Geology of Area

Tapti Daman sector located in NE part of western offshore basin. It consists number of structures like B-12/C-26, C-2, C-24, C-23, C-39 and North Tapti aligned NE-SW primarily gas bearing (Figure-1). C-24 Field is one of the structures explored during 1987-93 by drilling 8 exploratory wells out of which 4 wells (X-A, X-B, and X-C & X-D) have produced hydrocarbons from multi stack sands within Daman Formation.

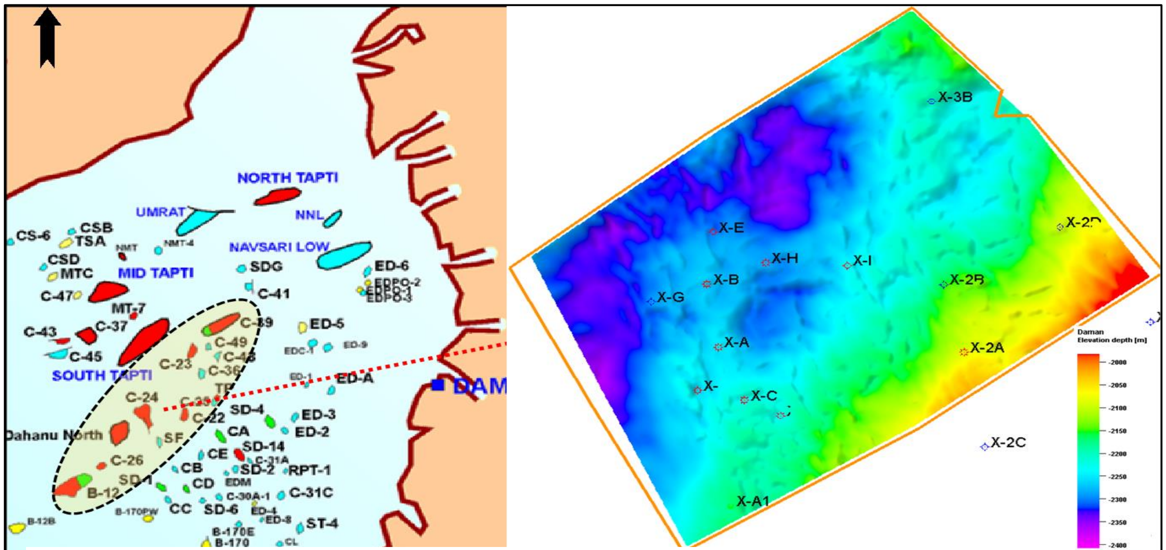

Figure 1: Location map of study area, C-24 Field, Tapti Daman Sector

Tapti-Daman block is located at the junction of the Cambay rift and the Son Narmada Lineament. It is a major tectonic depression 'Surat Depression' flanked by Saurashtra Homocline to the west/northwest, Eastern Homocline to the east, Diu Fault to the south and Diu arch to the west (Figure 2). The broad syncline rises towards the north against the ENE-WSW trending marginal faults, towards east in the NNW-SSE trending basin margin and to the south against the E-W trending Diu fault. Three prominent morpho-tectonic depressions viz. Navsari low, Purna Graben and Daman low exist in the central part along ENE-WSW trend (Biswas, 1982). The central horst separates the Daman Low from the Purna Graben. Initial extension regime during basin formation was obliterated by the younger tectonics resulting in the combination of high and low as present day structural setup in the area. The trans-tensional regime during Miocene, most pronounced in the Late Oligocene & younger sequences, has given rise to a number of structures. Widening of structures upwards, faults against the slope, shifting of crestal point in different levels, variable amplitude of the structures are some of the observed common features. Sediments deposited in the area are predominantly under strong influence of fluvial regime with fluctuating sea level toward the basinal side. The deposits are basically represented by thick, layered sequences of shale/claystone, sandstone, siltstone with occasional carbonates.

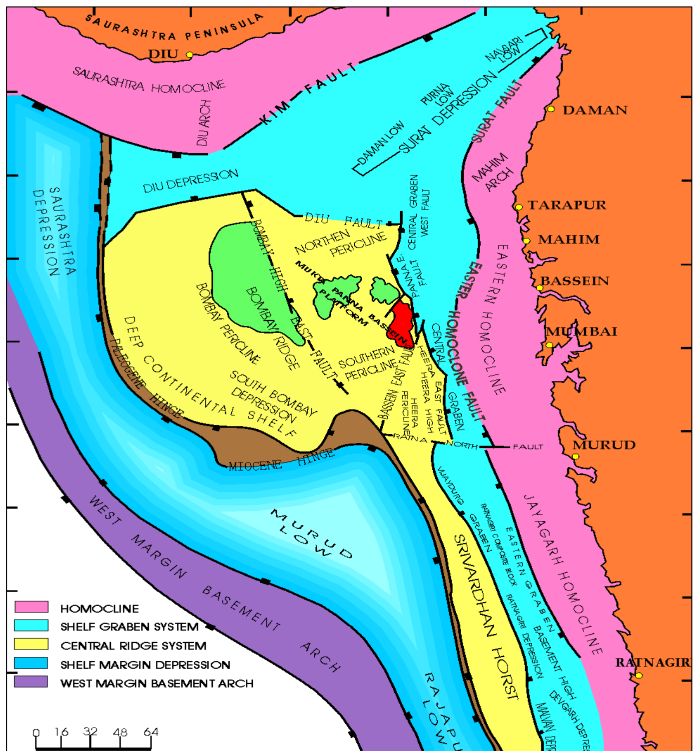

Figure 2: Tectonic framework of Western Offshore Basin

Sedimentation in Tapti Daman block started with deposition of Palaeocene to Early Eocene Panna Formation above the Deccan Traps of Upper Cretaceous age. Belapur and Diu Formations were unconformably deposited above Panna Formation in the entire area above which Lower Oligocene Mahuva Formation was deposited after a hiatus during Priabonian period. Mahuva Formation is divisible into two units viz., Lower and Upper Mahuva on the basis of dominance of sandy facies & sand-shale ratios.

Lower Mahuva is mainly shale with thin streaks of limestone, sandstone & siltstone and is a non -reservoir deposited in an overall transgressive setup, whereas Upper Mahuva contains some discontinuous & discrete sand bodies encased in a shale sequence and show the presence of hydrocarbon in the area. Upper Mahuva is unconformably overlain by Daman Formation of Late Oligocene age, which is a coarse clastics rich sequence and are primarily gas bearing. Subsequently, Mahim Formations, Tapti Formations and Chinchini Formation, deposited and were dominantly shale facies. The generalized stratigraphy is shown in the (Figure 3).

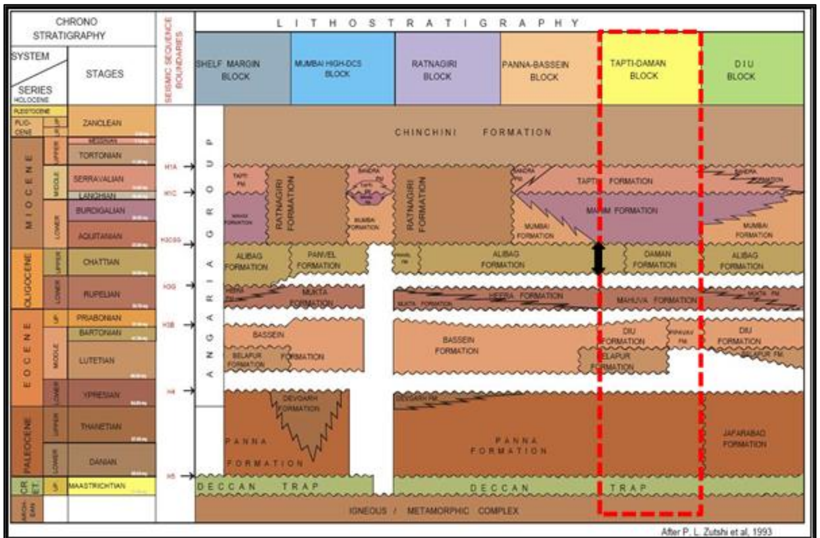

Figure 3: Generalized stratigraphy of Western Offshore Basin, India

Studies on heavy mineral suit and nature of detritus of Tertiary sediments suggest major sediment influx is from NE and a minor contribution may be from the weathered trap materials bordering the margin.

Methodology and workflow of pixel-based attribute

Mapping of any geological feature spatially and temporally is possible using seismic attributes. Most frequently used attributes in interpretation are frequency, amplitude and variance. The pixel-based attribute enables simultaneous attribute analysis in RGB color or Hue saturation value (HSV), which sharpened the continuous color for representation of multiple attributes to provide the geological interpretation (Laake, 2013; Laake, 2013b). Results obtained from pixel based RGB volumes show the structural lineaments and structure sharpened RGB image cube. It works similar to remote sensing imaging processing principle, where it assigns the color code point by point to pixels. The RGB image codes represent the physical properties such as frequency, amplitude and velocity as colour shades. Structural information is contained in the boundaries between areas of different color and amplitude. The conversion from RGB to HSV separates the pure color information in the hue band from

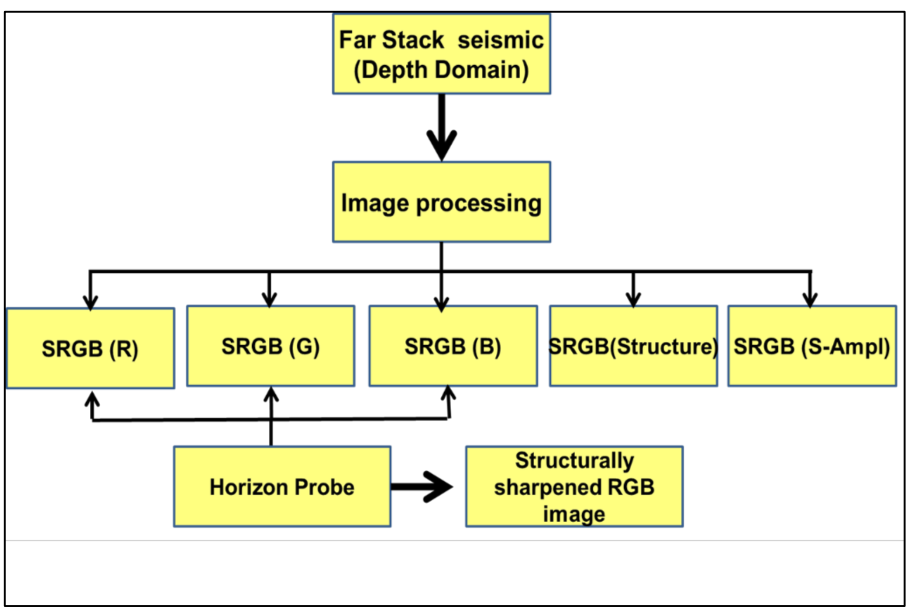

Figure 4: Workflow adopted for pixel based attribute extraction

the color-independent intensity information in the saturation band. The saturation band gradient provides edges which represent the structural lineaments contained in the data. Subsequently, structural lineaments are convolved with the RGB image that provide the structurally sharpened RGB image in combination of attributes. Image obtained from combining the attributes represent the geological character more realistically than single attribute traditionally. The workflow used for attribute volume generation is given in Figure 4.

Results and discussion

The multi-stack sands within Daman formation mimic the response of relative sea level changes occurred during Late Oligocene (Singh U, et al., 2020; Singh U, et al., 2020). These sands are sporadic in nature with variable occurrence of hydrocarbon and named as Sand6A (the bottom most sand occurred on top of Mahuva Formation), Sand5, Sand-4, Sand3, Sand2A, Sand2 and Sand1 (Fig.5).

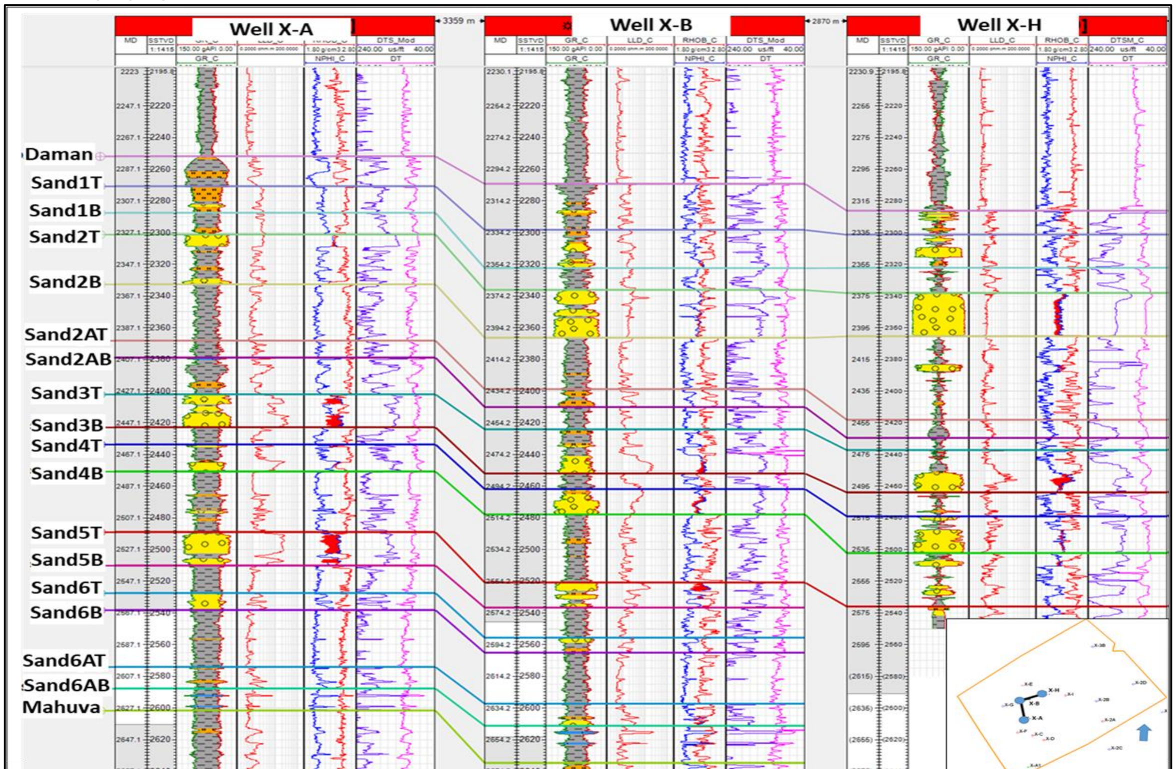

Figure 5: Electrologs correlation profile SW-NE showing different sands deposition in the area.

Sand2 has blocky log motif and its petrographic studies of well X-H and X-A represent quartz arenites to quartz wacke facies and associated sedimentary structures like ripple marks, cross lamination suggests channel sand/ bar sands of fluvial origin (Figure 6).

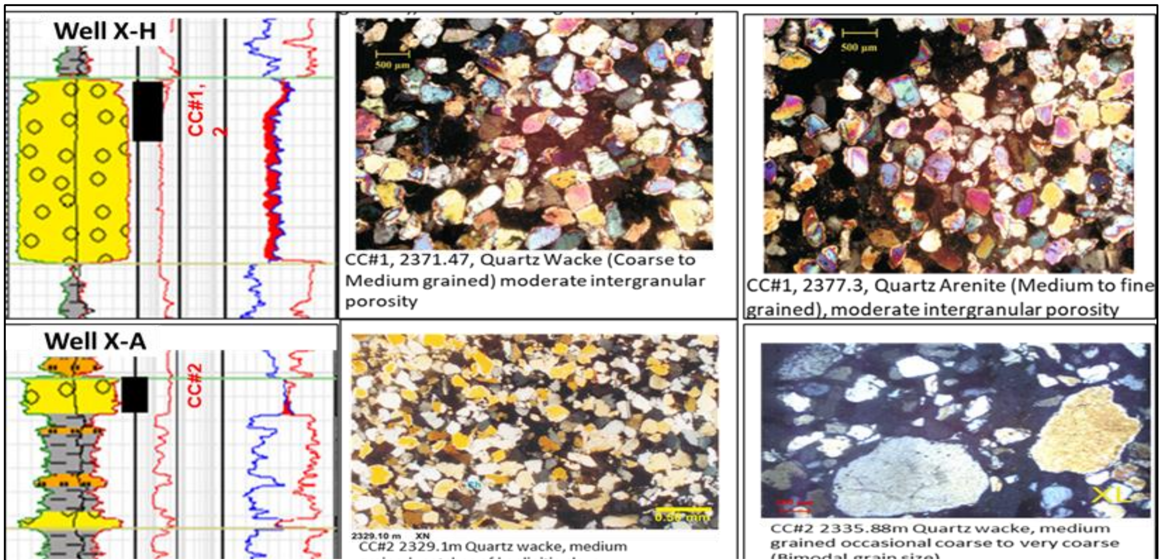

Figure 6: Block log motif of Sand2 and quartz wacke to quartz arenite medium to coarse grained facies.

In the study area, far angle stack amplitudes discriminate the sand facies and non-sand facies more rationally. Analysis of amplitude burst on far angle stack represented both gas filled sands as well as brine sands. Therefore, far angle stack is considered as a proxy to capture the sand bodies. The given workflow generates five different sharpened volumes SRGB (R), SRGB (G), SRGB (B), SRGB (structure) and SRGB (s amplitude) in dynamic color range. Structurally sharpened SRGB volumes were blended in horizon probe to find out the geological feature in seismic data. For each sand equivalent depth surfaces were used in horizon probe to delineate the individual sands geometry. The results obtained from horizon probe are shown in figure.7 A) and B) which correspond to the sand1 and Sand2 geometry of sands. Horizon probe played in pay equivalent sample to sample has delineated the sand geometry at specific depth, which were unable to get in window-based attributes.

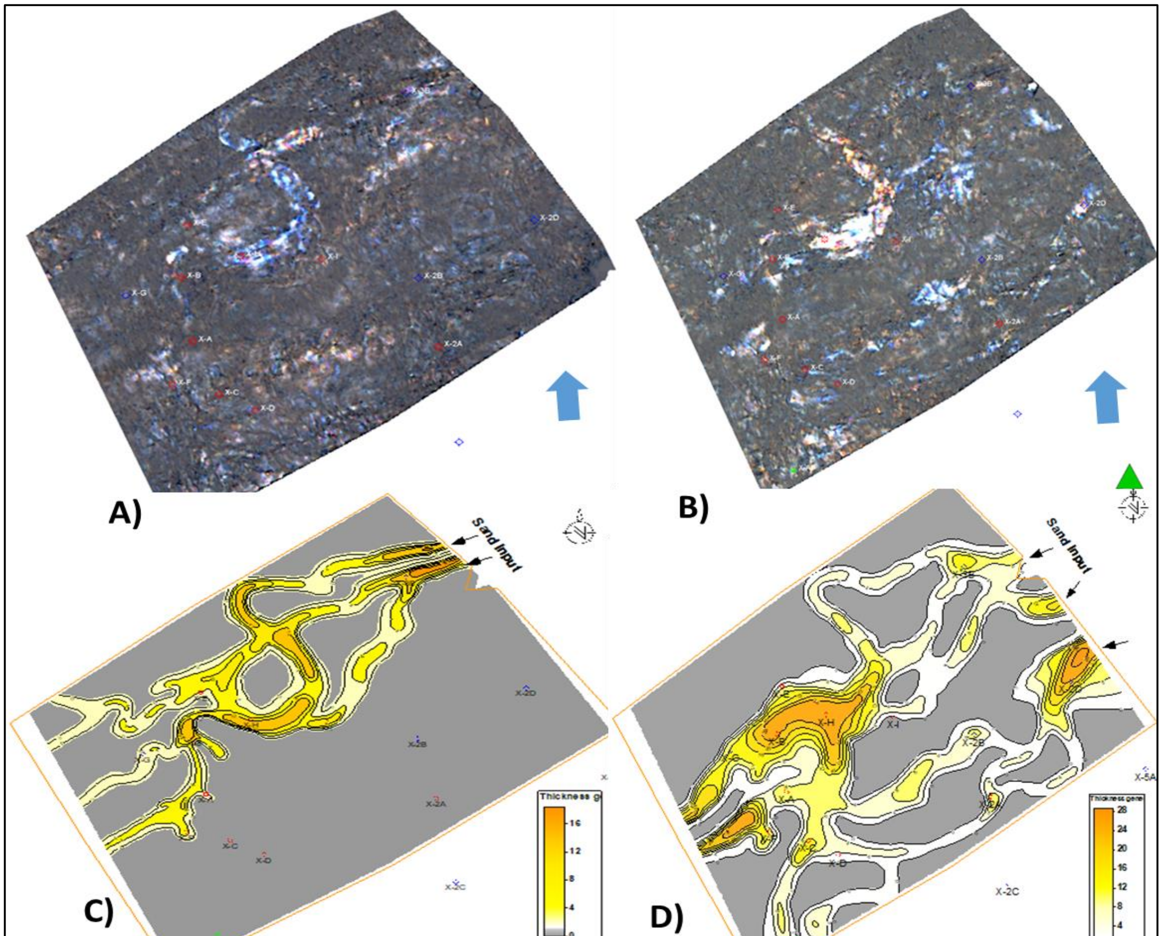

Figure 7: Delineation of channel geometry using pixel-based attribute for Sand1 in picture A), Sand2 in picture B) Sand map preparation using well based thickness and trend from attribute for Sand1 in picture C) and Sand2 in picture D).

Conclusion

Geologically complex multi stack channel bar system of Daman Formation is deposited under tidal influence. Mapping of spatial continuity of individual sands are possible using seismic attributes, whereas conventional window-based attribute methodology averages the property value. Therefore, an approach for mapping the boundaries of geological features within each units using SRGB technique provide the better information contained within the seismic data without averaging the properties. Response of SRGB volumes provided in dynamic color range and combining these attribute layer by layer or slice by slice represented sand channel system movement vertically as well horizontally. The channel geomorphology demarked using SRGB volume in horizon probe has validated the sand observed in all the wells within study area

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