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Depositional System and Reservoir Characterization of Miocene Basal Sand using Spectral Decomposition Technique, Cambay Basin

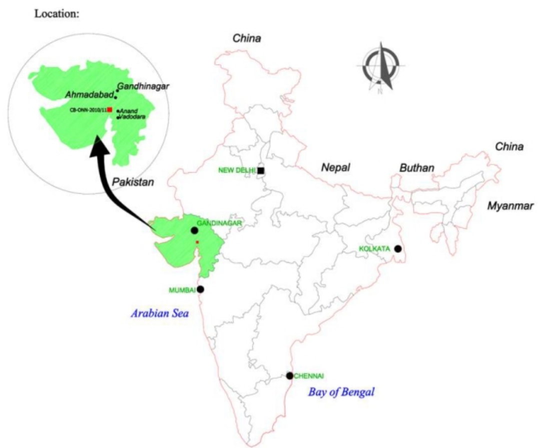
Abstract

Miocene basal sand (MBS) is one of the important producing hydrocarbon bearing sand in Cambay basin. Miocene basal sand is better developed towards the southern part (Cambay-Tarapur tectonic block) of Cambay basin. The aim of this study is assessment of the depositional environments of MBS sands based on the integration of well logs and seismic attribute analysis. In this study, spectral decomposition technique is applied to the imaging and mapping of geologic discontinuities and channel delineation at Miocene Basal sand level. Spectral decomposition unravels the seismic signal into its constituent frequencies. Since the stratigraphy resonates at wavelengths dependent on the bedding thickness, the interpreter can image subtle thickness variations and discontinuities. From the study, one distinctive channel and another branching of that channel were delineated in the area, and reservoir facies were proven by the drilled well data. It has been found that Miocene Basal Sands are mainly deposited in tide dominated marginal marine environment in the study area.

Introduction

The Cambay basin is a Tertiary intra-cratonic rift basin in the western onshore part of India, came into existence at the close of Cretaceous. This is a linear NNW-SSE trending basin. The basin is divided into five tectonic blocks separated by major cross trends. They are (i) Sanchor-Patan (ii) Mehsana-Ahmedabad (iii) Tarapur-Cambay (iv) Broach-Jambusar (v) Narmada-Tapi blocks from north to south.

The study area is located in the Cambay-Tarapur tectonic block of Cambay basin (fig.1). The Nawagam-Wasana high is existing in the north of the study area. The generalized stratigraphy of the study area is given in Table-1.



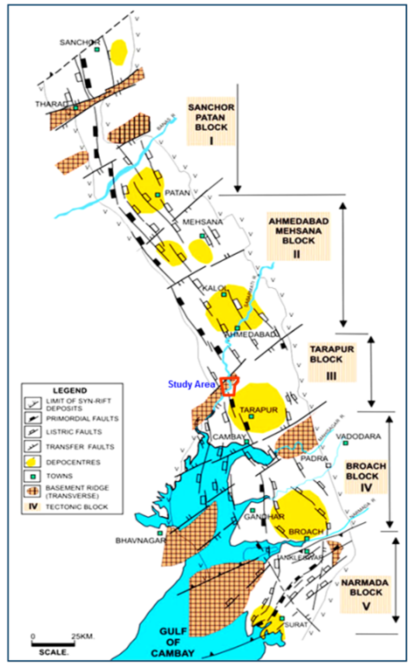


Fig.1 Location of the study area

	Sanchor-Patan block	Mehsana-Ahmedabad block	Tarapur-Cambay block	Jambusar-Broach block	Narmada-Tapti block	Generalised Lithology
Recent to Pliocene	Gujarat Alluvium	Gujarat Alluvium	Gujarat Alluvium Jambusar Fm Broach Fm	Gujarat Alluvium Jambusar Fm	Gujarat Alluvium	
Upper Miocene			Jhagadia Fm			
Middle Miocene			Kand Fm			
Lower Miocene	Kathana Fm	Kathana Fm	Babaguru Fm Tarkeshwar Fm	Tarkeshwar Fm	Tarkeshwar Fm	
Oligocene	Tarapur Fm	Tarapur Fm	Dadhar Fm	Dadhar Fm	Dadhar Fm	
Upper Eocene	Kalol Fm	Kalol Fm	Kalol/Vaso Fm	Anklesvar Fm	Anklesvar Fm	
Middle Eocene						
Lower Eocene	Kadi Fm / U. Cambay Shale Fm M. Cambay Shale Fm Lower Cambay Shale Fm	Kadi Fm / U. Cambay Shale Fm M. Cambay Shale Fm Lower Cambay Shale Fm	Cambay Shale	Cambay Shale	Cambay Shale	
Palaeocene	Olpad/Vagadkhol Formation	Olpad/Vagadkhol Formation	Olpad/Vagadkhol Formation	Olpad Formation	Olpad Formation	
U Cretaceous			Deccan Trap basalt			

Table-1: stratigraphic table of Cambay basin (adapted from Raju & Srinivasan 1993 and Wani et al. 1995)

Depositional Environment analysis using Spectral Decomposition technique

Seismic data, being non-stationary in nature, have varying frequency content in time. Time–frequency decomposition (also called spectral decomposition) of a seismic signal aims to characterize the time-dependent frequency response of subsurface rocks and reservoirs. Spectral decomposition unravels the seismic signal into its constituent frequencies. Since the stratigraphy resonates at wavelengths dependent on the bedding thickness, the interpreter can image subtle thickness variations and discontinuities. (Ref: Use of spectral decomposition technique for delineation of channels at Solar gas discovery, offshore West Nile Delta, Egypt: Adel A.A. Othma, M. Fathy, Ali Maher)

Methodology

Here the Filter Frequency attribute has been used as the attribute of choice to perform the spectral decomposition and RGB blending. This attribute gives better spatial resolution to the resulting RGB blend and makes it easier to reveal geological information and also simplifies interpretation of the result.

Prior to running the spectral decomposition, the dominant frequency of the seismic data is measured (approximately 25 Hz). The channel fill tuning frequency may be either greater or less than the overall seismic dominant frequency. Spectral decomposition is run in order to analyze different frequencies of the seismic volume.

Three seismic Filter frequency cube and their envelop cube at central frequency of 20 Hz, 30 Hz and 40 Hz were created. Horizon probe with a window of MBS+/-5 millisecond were created using RGB blending of the envelop cubes at central frequency of 20 Hz, 30 Hz and 40 Hz. The Red–Green–Blue (RGB) colour blended maps; where each colour corresponds to a specified frequency range. The three frequency ranges are: 20 Hz (the lowest frequency range in the seismic dataset) in Red colour, 30 Hz (the dominant frequency in the seismic dataset) in Green colour, and 40 Hz (the highest frequency range in the seismic dataset) in Blue colour.

Interpretation

In this study, one N-S trending channel was identified along with a branching of that channel, One channel is passing through NE corner of the study area (Fig:2). The branching channel runs parallel to the first channel in the northern part of the study area and eventually converges and flow as a single channel towards southern part of the study area.

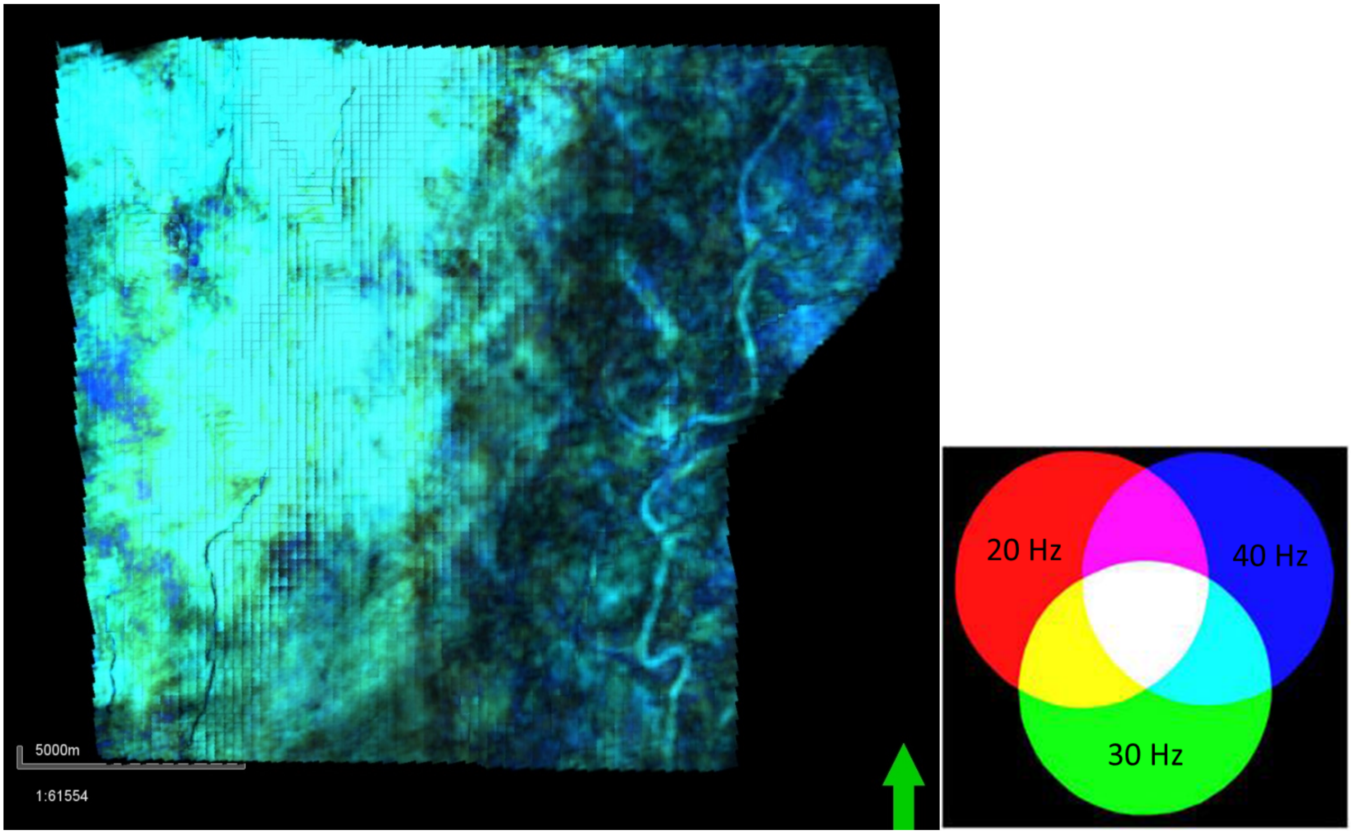


Fig.2 Horizon probe with a window of MBS+/-5 millisecond using RGB blending of envelop of Filter frequency cubes at central frequency of 20 Hz, 30 Hz and 40 Hz.

Well Data Analysis

Three wells were drilled in the eastern part of the study area (Fig.3) and the log characters are presented below. The log characters are depicting the characters of Tidal environment. The gamma log shape of Well-A and Well-B displays cylindrical serrated sequence with a sharp (erosional) lower contact and a sharp to gradational upper contact (within the blocky profile, there are some weak fining upwards trends exhibiting a hybrid of marine and fluvial origin). This log characters suggest overall a Tidal channel in nature. The Gamma ray log shape of Well-C displays a serrated bell (sometimes symmetrical) log curve with gradational top, which suggest a Tidal flat to Tidal Bar environment.

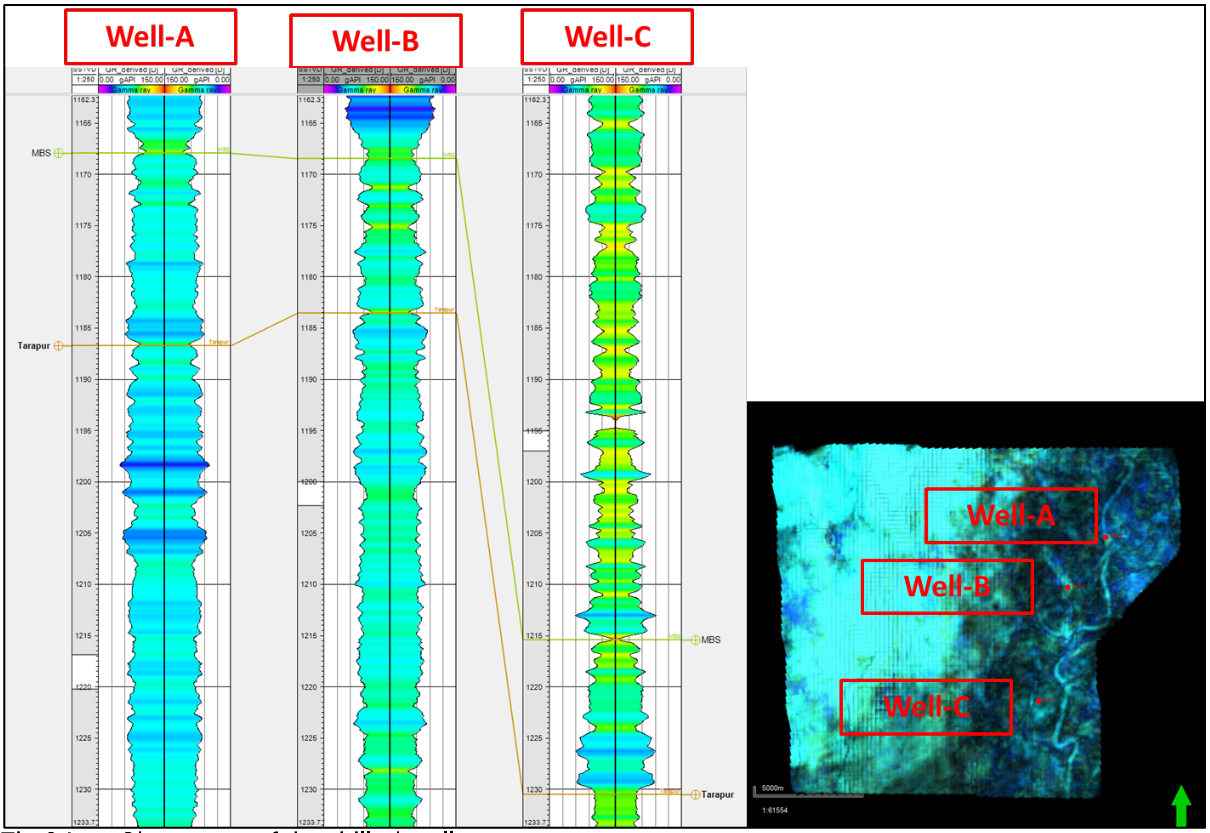


Fig.3 Log Characters of the drilled wells

Interpretation

MBS reservoir sands were deposited in an overall tide dominated marginal marine environment from north of the study area towards south. Main tidal transport direction is from north to south as deciphered from the spectral decomposition analysis. Wireline log pattern has been interpreted and mainly 2 distinct log characters are identified. At Well-A and B the environment is Tidal channels and at Well-C Tidal Flat to Tidal bar environment.

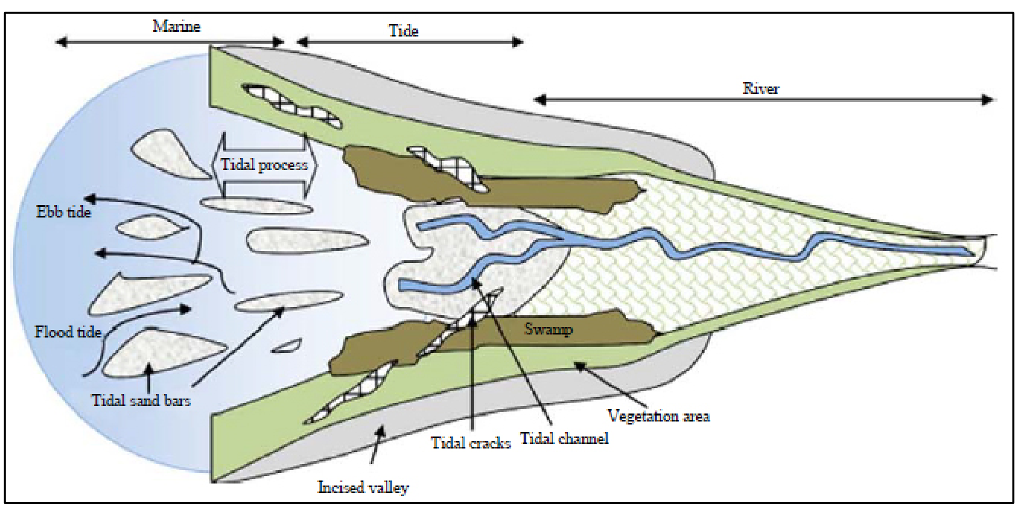


Fig.4 Schematic diagram of Tide Dominated environment

Conclusion

The spectral decomposition provides substantially more detail and fidelity than full bandwidth conventional attributes. It reveals stratigraphic and structural edges as well as relative thickening and thinning. It allows viewing subsurface seismic interference at discrete frequencies.

The study reveals one N-S trending along with a branching of that channel. One channel is passing through NE corner of the study area. The branching channel runs parallel to the first channel in the northern part of the study area and eventually converges and flow as a single channel towards southern part of the study area. The wireline log characters are also showing that the MBS reservoir sands were deposited in an overall tide dominated marginal marine environment from north of the study area towards south.

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