Miocene Fluvial-Channel System Stratigraphic Traps delineation using Various Seismic Attributes: A Case Study for Near-field exploration opportunities in OIL's Operational Area in Upper Assam Basin.

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Keywords

Seismic attributes, Intensity of anomaly, Stratigraphic traps & fluvial channel

Abstract

The Upper Assam Basin is a foreland basin, bounded by the eastern Himalayan foot hills to the North, Mishmi Hills to the northeast and Assam Arakan fold thrust belt to the south. The sedimentary succession in the basin have been characterized with different depositional environments viz. Shallow Marine (Langpar & Lakadong+Theria: Paleocene-Eocene), Deltaic (Barail-Oligocene), Fluvial (Tipam-Early Miocene), Fluvial-Lacustrine (Girujan-Late Miocene) and Fluvial (Alluvium-Pleistocene).
The present study area is a prolific producer from Barail or Lower Tipam (Oligocene-Early Miocene) reservoirs with potential hydrocarbon accumulation in the overlying Upper-Tipam and Girujan (Mid-Late Miocene) Formations. As per the present understanding and testing in few wells, the hydrocarbon bearing reservoirs in the overlying Upper-Tipam & Girujan Formations are primarily found to be of stratigraphic nature & characterized by lenticular sand bodies difficult to correlate due to their discontinuous nature.
In the present study, an attempt has been made to qualitatively and quantitatively delineate the shallower target reservoirs within Upper Tipam-Girujan Formations (Mid-Late Miocene) using various seismic attributes viz. Root Mean Square(RMS) & Sweetness etc. Strong anomalous zones, indicative of suitable stratigraphic entrapments have been identified, correlated & validated through existing drilled wells within the limits of anomaly. The identified anomalous patterns have also been found to be well supported by inverted properties viz. acoustic impedance, Vp/Vs & lamda-rho.
Detailed analysis has been carried out, specifically based on the intensity of observed seismic attribute anomaly and the following three stage behavior has been observed.
Stage1: demarcated with strong seismic attribute anomaly and correlated with the wells having presence of hydrocarbon within the same reservoir.
Stage2: demarcated with feeble seismic attribute anomaly and correlated with the well having presence of reservoir without hydrocarbons.
Stage3: demarcated with absence of seismic attribute anomaly and correlated with the well having absence of reservoir.
As per the geological understanding, the observed discontinuous anomalous amplitude are similar to a typical network of fluvial deposition, however they lack overall sinusoidal characteristics.
Girujan acts as the regional cap rock in most part of the Assam shelf basin and commercial entrapment of hydrocarbon is found in the reservoirs just below this regional cap (Tipam Sand) and also within Girujan Formations. Therefore, it increases the possibility of HC accumulations within the discrete reservoir facies. As these reservoirs are not yet targeted with focused approach, this study is an integrated approach for more detailed analyses for future near field exploration opportunities, with high chance of success.

Introduction & Study Area

The Upper Assam Basin, situated in the eastern Himalayan foothills, is a category-I petroliferous sedimentary basin with significant hydrocarbon potential. It is bounded by the Mishmi Hills to the northeast, the Assam Arakan fold thrust belt to the south, and the eastern Himalayan foothills to the north. The sediments deposited in this basin (ranging from thickness: 7 KM to 10 KM) exhibit diverse depositional environments, including shallow marine, deltaic, fluvial, and lacustrine. The focus of this study is a specific area within the Upper Assam Basin, which has been a prolific producer from the Barail or Lower Tipam reservoirs (Oligocene-Early Miocene).

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The Upper-Tipam and Girujan formations (Mid-Late Miocene) overlying these reservoirs have shown potential for hydrocarbon accumulation. However, the reservoirs in these formations are stratigraphic in nature and characterized by lenticular sand bodies that are difficult to correlate due to their discontinuous nature. Location of the study area has been provided as **Figure-1**.

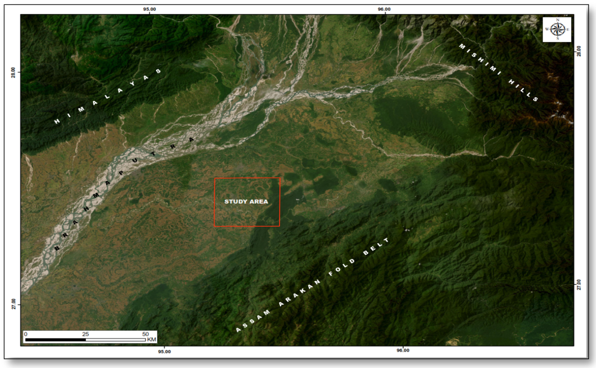


Figure-1: Base map showing Location of the study area.

Objective

The primary objective of this study is to qualitatively and quantitatively delineate the shallower target reservoirs within the Upper-Tipam and Girujan Formations using various seismic attributes. Seismic sections highlighting the targeted events have been provided as **Figure-2**.

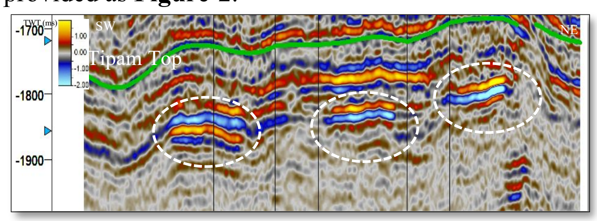


Figure-2a: Seismic Section showing Target events within Tipam Formations (close to Tipam Sandstone 40 or TS40)

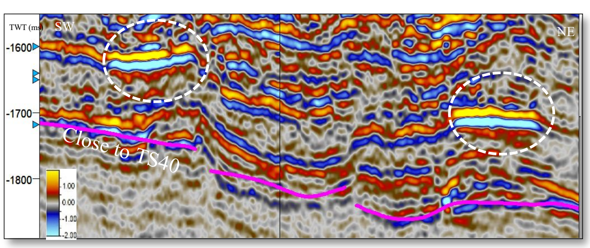


Figure-2b: Seismic Section showing Target events close to Tipam Top

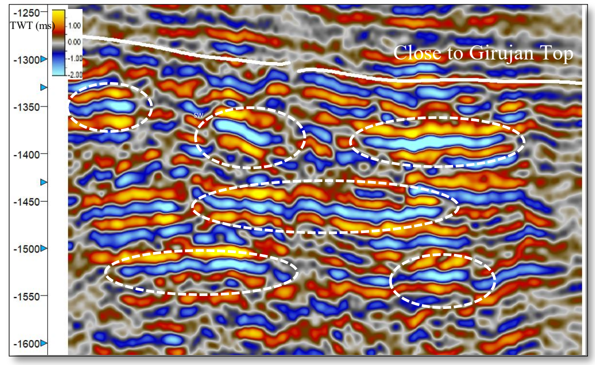


Figure-2c: Seismic Section showing Target events within Girujan Formations

Methodology

The study utilizes seismic attributes, primarily Root Mean Square (RMS) and Sweetness, to identify strong anomalous amplitude zones indicative of suitable stratigraphic entrapments.

RMS is a most commonly used post stack amplitude based seismic attribute; it computes the square root of the sum of squared amplitude values divided by the number of samples within the specified window. The windowed amplitudes are basically used as a simple and quick means to identify interesting zones of hydrocarbons. The squaring of the amplitude values within the window or along the surface horizon gives the high amplitudes maximum opportunity to stand out above the background contamination. As far as Sweetness seismic attribute is concerned, it is used to highlight the clean, thick reservoir along with hydrocarbons contained within. Sweetness is calculated by dividing the instantaneous amplitude (amplitude envelope) by the square root of the instantaneous frequency. In general, using sweetness seismic attribute, higher frequency events are devalued, and low frequency events are highlighted. Geologically, the shales are intrinsically laminated unlike sands which can be clean if not laminated with thin interbedded shales.

In order to track the spatial distribution of Seismic attribute anomaly, horizon slices have been generated using the nearest interpreted horizon and applying appropriate window after extensive quality checking. The anomalous zones observed through seismic attribute analysis are correlated and validated using drilled wells within the study area. The intensity of amplitude variations in the seismic attribute data is also considered for correlating lateral reservoir development. In addition to seismic attributes, inverted properties such as acoustic impedance, Vp/Vs ratio, and lamda-rho are employed to support the identified anomalous zones.

Results & Discussion

Detailed analysis based on the intensity of observed seismic attribute anomalies has led to the categorization of three stages of behaviors. Stage 1 is characterized by a strong seismic attribute anomaly, which correlates with nearby wells showing the presence of hydrocarbons within the same reservoir. Stage 2 exhibits a feeble seismic attribute anomaly and corresponds to nearby wells with reservoirs lacking hydrocarbons. Stage 3 demonstrates the absence of a seismic attribute anomaly, corresponding to nearby wells without any reservoir presence.

In support to above, one example within the study area, has been provided as **Figure-3** showcasing the behavior of different stages observed during the analysis.

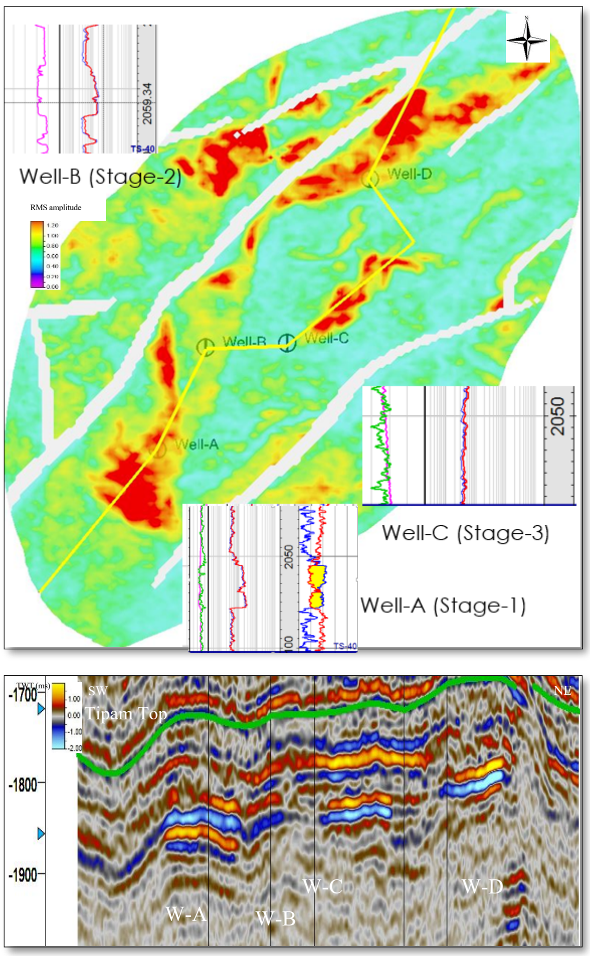


Figure-3: showing 3 stage behavior of seismic attribute anomaly (RMS amplitude) versus reservoir characteristics

Further, seismic attribute results along with inversion results supporting the anomalous amplitude behavior have also been provided as **Figure-4.**

For target close to TS40 within Tipam Formations, the reference basemap & seismic section are the same as provided in **Figure-3**.

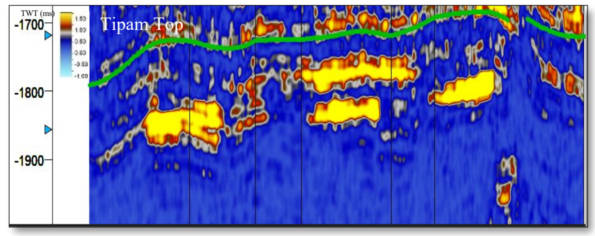
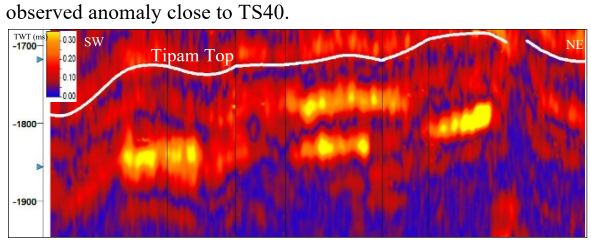


Figure-4(a1): showing RMS Seismic attribute section through the observed anomaly close to TS40.



*F*igure-4(a2): showing Sweetness Seismic attribute section through the observed anomaly close to TS40.

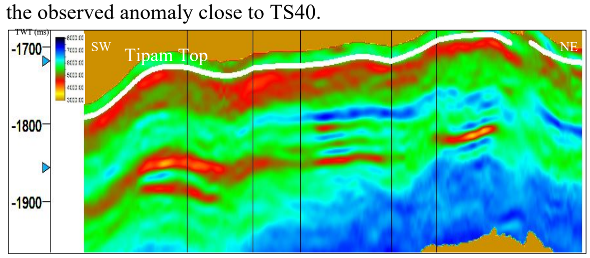


Figure-4(a3): showing Impedance section through the observed anomaly close to TS40.

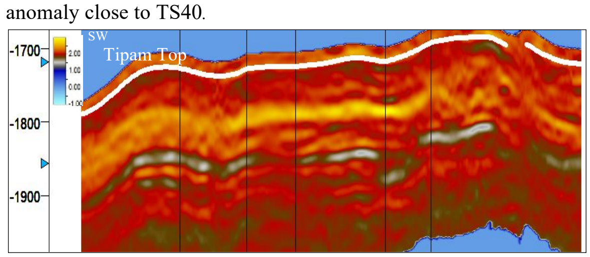


Figure-4(a4): showing Vp/Vs Seismic attribute section through the observed anomaly close to TS40.

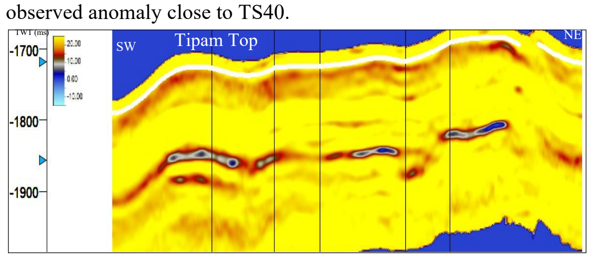


Figure-4(a5): showing Lamda-rho Seismic attribute section through the observed anomaly close to TS40.

For target Formations close to Tipam Top, the results have been provided below.

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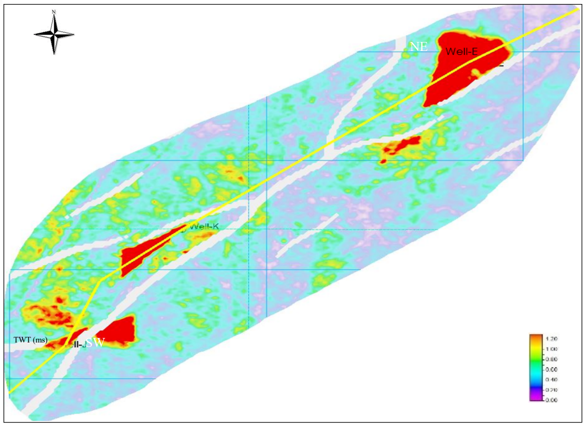

Figure-4(b1): showing basemap of the observed anomaly (RMS amplitude) close to Tipam Top.

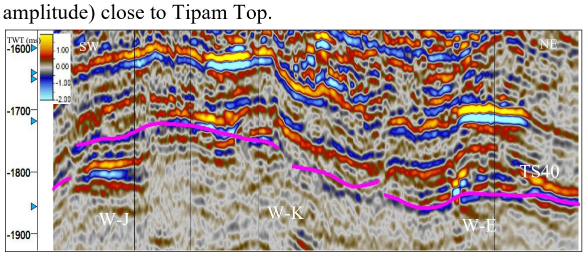

Figure-4(b2): showing Seismic section through the observed anomaly close to Tipam Top.

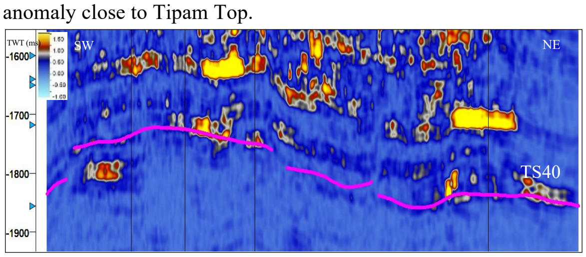

Figure-4(b3): showing RMS seismic attribute section through the observed anomaly close to Tipam Top.

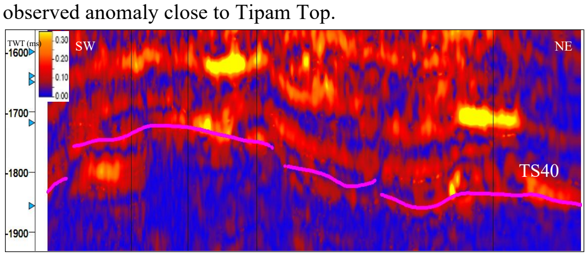

Figure-4(b4): showing Sweetness Seismic attribute section through the observed anomaly close to Tipam Top.

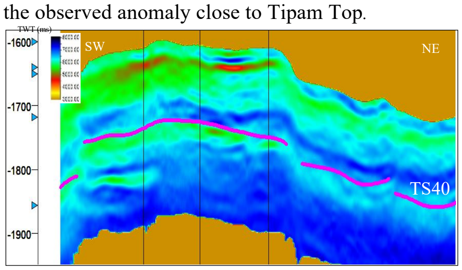

Figure-4(b5): showing Impedance seismic attribute section through the observed anomaly close to Tipam Top.

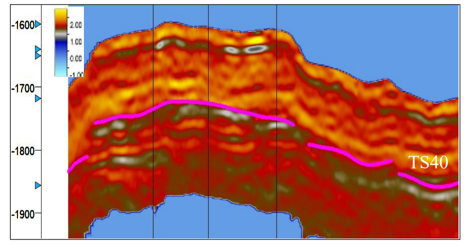

Figure-4(b6): showing Vp/Vs seismic attribute section through the observed anomaly close to Tipam Top.

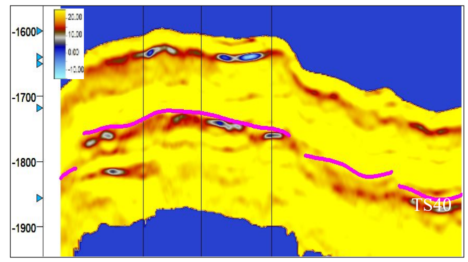

Figure-4(b7): showing Lamda-rho seismic attribute section through the observed anomaly close to Tipam Top.

For target Formations within Girujan Formations, the results have been provided below.

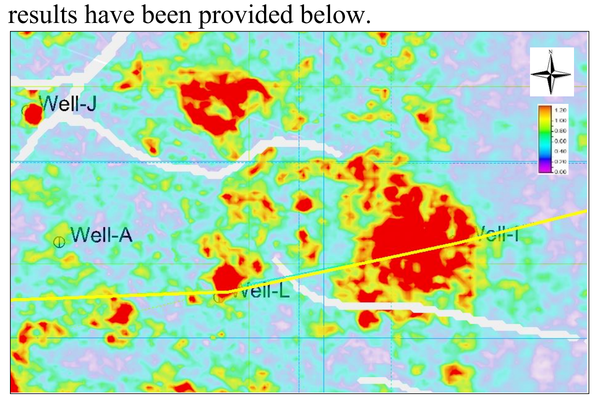

Figure-4(c1): showing basemap of the observed anomaly (RMS amplitude) within Girujan Formations.

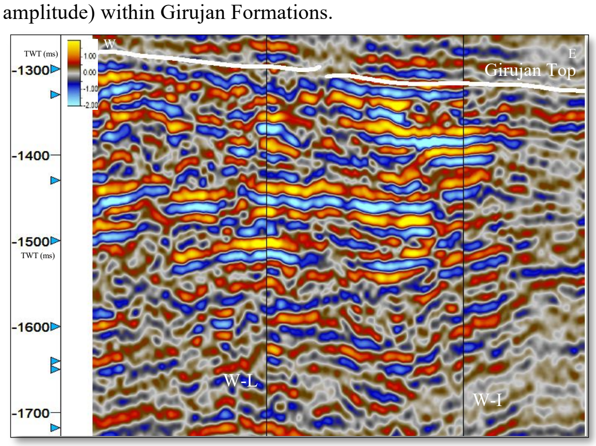

Figure-4(c2): showing Seismic section through the observed anomaly within Girujan Formations.

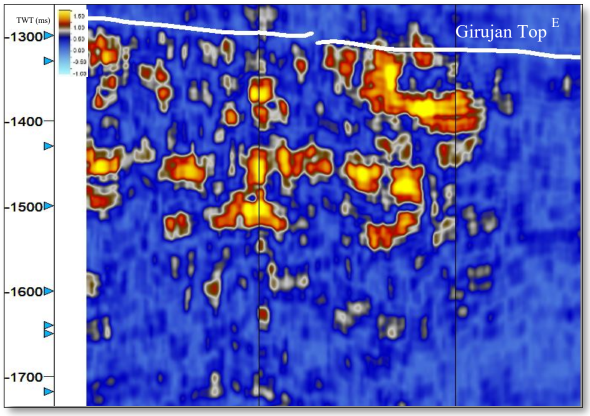

Figure-4(c3): showing RMS seismic attribute section through the observed anomaly within Girujan Formations.

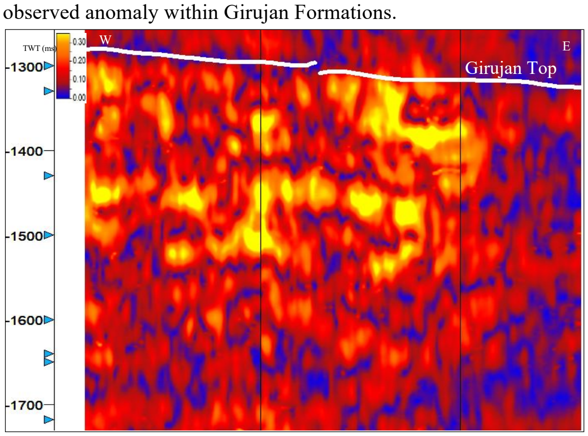

Figure-4(c4): showing Sweetness seismic attribute section through the observed anomaly within Girujan Formations.

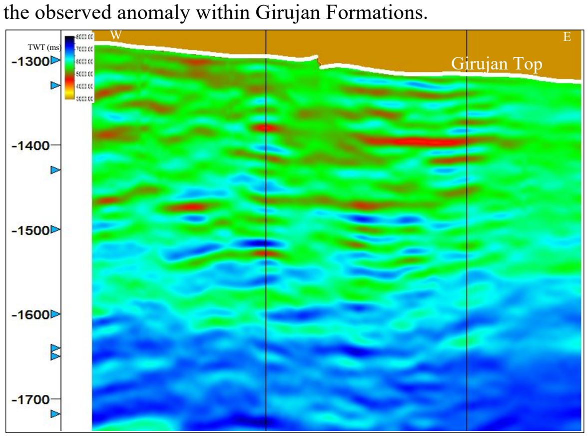

Figure-4(c5): showing Impedance seismic attribute section through the observed anomaly within Girujan Formations.

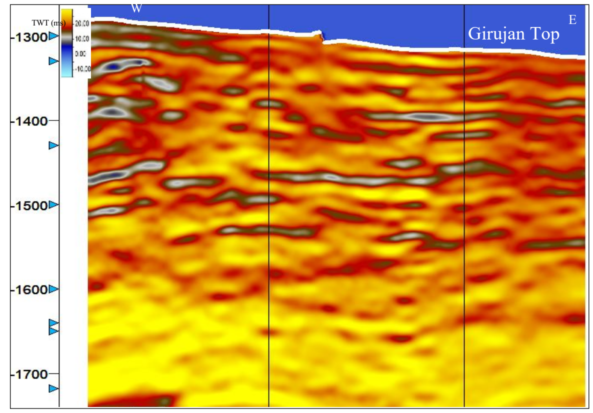

Figure-4(c6): showing Lamda-rho seismic attribute section through the observed anomaly within Girujan Formations.

As per the geological understanding of the area, the observed discontinuous anomalies seem to be the part of a fluvial deposition and are parts of a fluvial channel network, however, they lack overall sinusoidal characteristics. Spatial distribution of the identified anomalous patterns has been provided as **Figure-5**.

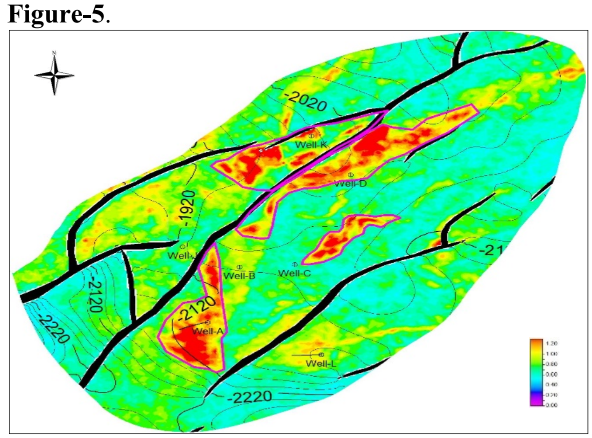

Figure-5a: Identified anomalous patterns (RMS amplitude) close to TS40 within Tipam Formations

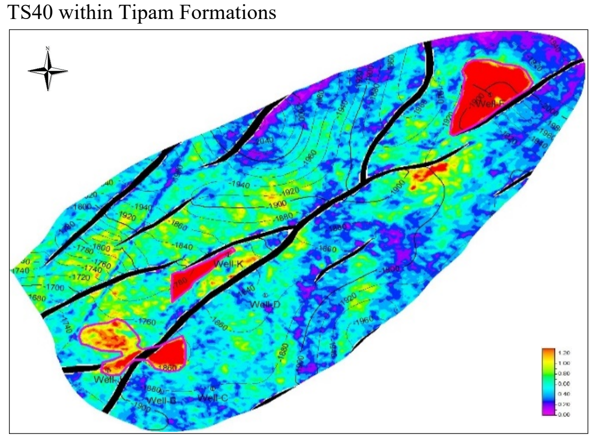

Figure-5b: Identified anomalous patterns (RMS amplitude) close to Tipam Top

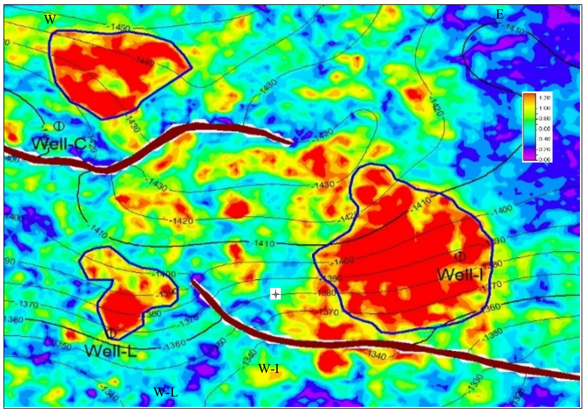

Figure-5c: Identified anomalous patterns (RMS amplitude) within Girujan Formations

Furthermore, it is observed that the Girujan Formation acts as the regional cap rock in most parts of the Assam shelf basin, with increasing thickness towards the south. Commercial hydrocarbon entrapment is found in the reservoirs just below this regional cap, specifically within the Tipam Sand. Consequently, there is an increased possibility of hydrocarbon accumulations within the discrete reservoir facies within the Girujan Formations. These reservoirs have not been targeted with a focused approach and present an opportunity for near-field exploration. A tentative geological section passing through the observed anomalous amplitude behavior and the nearby wells have been provided as **Figure-6**.

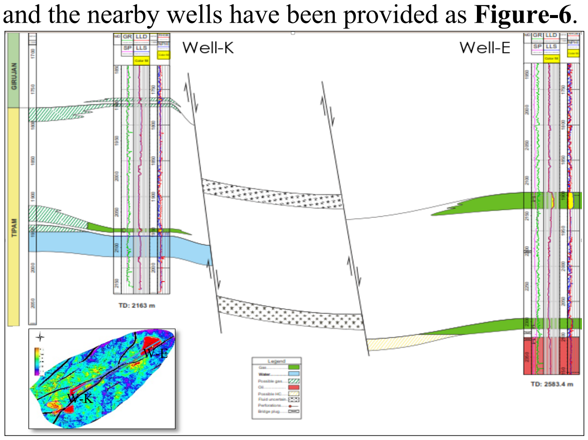

Figure-6a: Tentative Geological section passing through anomalous amplitude and the nearby wells within Tipam Formations.

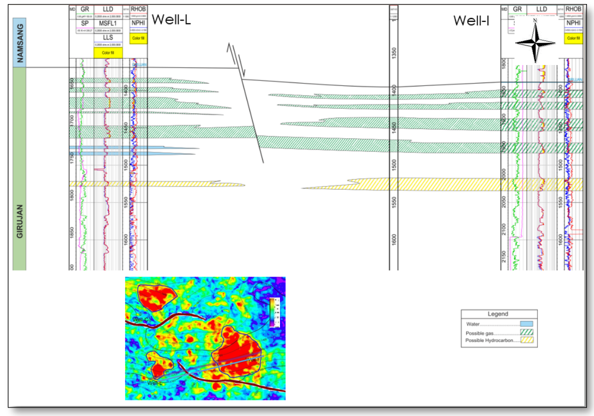

Figure-6b: Tentative Geological section passing through anomalous amplitude and the nearby wells within Girujan Formations.

Conclusion

- This study presents an integrated approach for the detailed analysis of the less explored Upper-Tipam and Girujan Formations within the study area. The utilization of various seismic attributes, along with the correlation and validation from drilled wells, has provided insights into the stratigraphic traps within these Formations. The results indicate the potential for near-field exploration opportunities in the targeted clastic reservoirs, with a high chance of success.

- The findings of this study demonstrate the importance of seismic attribute analysis in delineating stratigraphic traps in the Miocene fluvial-channel system. The integration of RMS, Sweetness, and other seismic attributes has allowed for the identification of anomalous zones that are indicative of potential hydrocarbon accumulations. Correlation with well data has further validated the presence of hydrocarbons in certain reservoirs within the Upper-Tipam and Girujan Formations.

- Additionally, the study highlights the significance of lateral facies variation and its correlation with seismic attribute intensity. This information can assist in understanding the spatial distribution of reservoirs and can be used to optimize future drilling and production strategies. Proper identification and analogy of different stages based on seismic attributes, provides a useful framework for assessing the potential of hydrocarbon in similar geological settings.

Overall, this study emphasizes the importance of integrating seismic data attribute analysis, well & production data and geological understanding in targeting the stratigraphic traps within the Miocene fluvial-channel systems. The delineation of such traps and the identification of potential hydrocarbon accumulations provide valuable insights for near-field exploration in the Upper Assam Basin. The findings of this study can guide future exploration and production activities, leading to improved hydrocarbon recovery and increased success rates in the area.

- Views expressed are those of authors only.

Acknowledgement

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