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Identification of Stratigraphic Play Potential within the Jalangi Formation using High-Resolution Sequence Stratigraphy in the Shelfal Part of Bengal Basin, India*

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Abstract

Modern exploration for hydrocarbons is primarily focused on both conventional and unconventional traps using large 3D seismic datasets. This is becoming common because explorations for stratigraphic traps are challenging and require sophisticated techniques and software to properly image and make valid interpretations. The shelfal part of Bengal Basin, which is an onland basin (Figure 1 and Figure 2), was selected for the application of sequence stratigraphy using a high resolution and automated method of seismic interpretation.

The Bengal Basin is a pericratonic basin and holds large thickness of sediments starting from the Mesozoic to the Tertiary. Since the inception of exploration activities in Bengal Basin, 42 wells have been drilled in the shelfal part of the basin with significant number of hydrocarbon indications observed in different stratigraphic units, starting from Gondwana sequence to Miocene sequence, but none of them has yielded hydrocarbon in commercial quantities. Earlier the thrust of exploration was mostly aimed at probing the fault closures, reefal buildups and shallow channel sands, most of which failed to provide the break through, mainly owing to absence of any structural entrapment conditions. In absence of any significant structural traps, it is now believed that future of Bengal Basin lies in the exploration and exploitation of the hydrocarbon accumulations mainly in stratigraphic traps.

In the present study, the primary focus was concentrated on the possible stratigraphic plays within Paleogene sequences due to the presence of good source and reservoir facies as evident from the drilled wells vis-a–vis considerable number of hydrocarbon shows observed in the basin (Figure 3 and Figure 4). While studying the Paleocene section (Jalangi Fm.) of the Bengal shelf, it is understood that the Jalangi Fm. is a complex one and its depositional environment is a combination of subaqueous delta to lagoonal to shallow marine and different depositional processes were working together simultaneously (Figure 5).

Analysis of a window based RMS amplitude attribute generated on 3D seismic volume for the middle and lower part of the Paleocene sequence clearly brought out a few high amplitude elongated features/geobodies aligned parallel or at low angle to the paleo-coastline prevailing. (Figure 6, Figure 7, Figure 8, Figure 9).

A high-resolution seismic chronostratigraphy approach was adapted to assess the geometric relationships of depositional cycles and lithologic associations of these geobodies in response to relative sea-level changes. The main step entailed seismic interpretation using closely spaced semi automatically generated seismic horizons from seismic reflection data. A 3D seismic chronostratigraphy cube was built to interactively assess the basin history through the Paleocene sequence of Bengal Shelf, to assess the varied stratal architectures of the sequence. The auto tracked seismic horizons were further used to carry out 3D "Wheeler transformation". Wheeler transform is an equivalent of the Wheeler diagram extracted from a seismic data set. Wheeler diagram had long been used by geologists for better understanding of the depositional history of the sedimentary packages. The stratigraphic features are best understood when studied simultaneously in the "Wheeler domain" and in the depositional domain/structural domain. This integrated technique represents a unique methodology for exploration of stratigraphic traps (Figure 10 and Figure 11).

Based on this study, the geo-bodies have been interpreted as "Barrier Bar" part of the barrier island system. These are narrow bodies of sediments, elongated parallel to the depositional strike, or strike of the shoreline. This body of sediment is composed predominantly of sand that originates on the beach shoreface, foreshore, and backshore and is commonly tens to hundreds of meters broad, up to hundreds of kilometers long, and 10m to 20m thick (Reineck and Singh, 1980). It may be interrupted in many places along its length by deltaic, estuarine, bay, and other deposits where these features cut across the beach (Figure 12 to Figure 13).

In order to understand whether the Barrier Bar is transgressive or regressive in nature, "Systems Tract interpretation" was carried out. To perform a Systems tract interpretation, Four Tracts depositional sequence model (Catuneanu, 2002) was selected. Once the interpretation was completed a "Base level" curve was generated alongside the Systems tracts which give the clear picture of transgression and regression cycles within the package. Then the interpreted Systems tracts with coloured coding were overlaid on the seismic. The combined seismic section suggests that the Barrier Bar was part of "Transgressive Systems Tract (TST)". The bodies observed on seismic clearly suggest that there were stack of bars deposited at some places within the basin while at upper to middle part of the sedimentary pack there were signatures of landward migration of bar. It was also observed that these bars were separated by thin layers of transgressive shale that might act as good cap rock for these geo bodies (Figure 14 to Figure 15).

The geo bodies are within the Jalangi Fm., the distribution of which is wide spread in Bengal Basin and were deposited during a transgressive-regressive sea level cycle. During that time, thick marine shale packages, with thin coal seams were deposited in the shelfal part. Earlier studies suggest that the Jalangi Formation shale has good source rock potential over the entire shelf part and thought to have greatest potential for oil generation in Bengal Basin. Therefore, any hydrocarbon generation within this sequence is likely to charge these stratigraphic features/ geo-bodies, which can act as a good reservoir and enhance the stratigraphic play potential of the formation.

Acknowledgements

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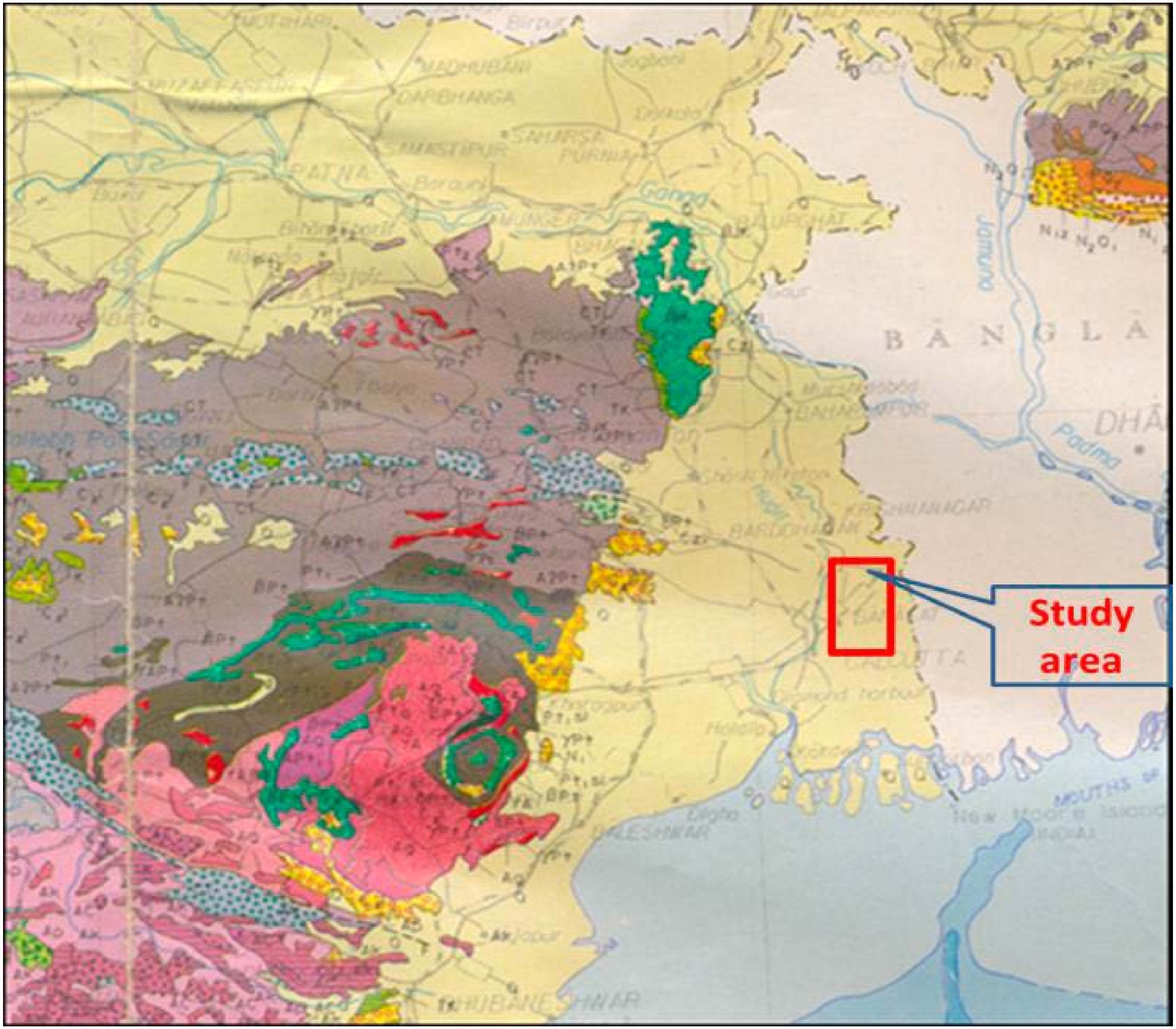

Figure 1. Geological map of Bengal Basin showing the study area.

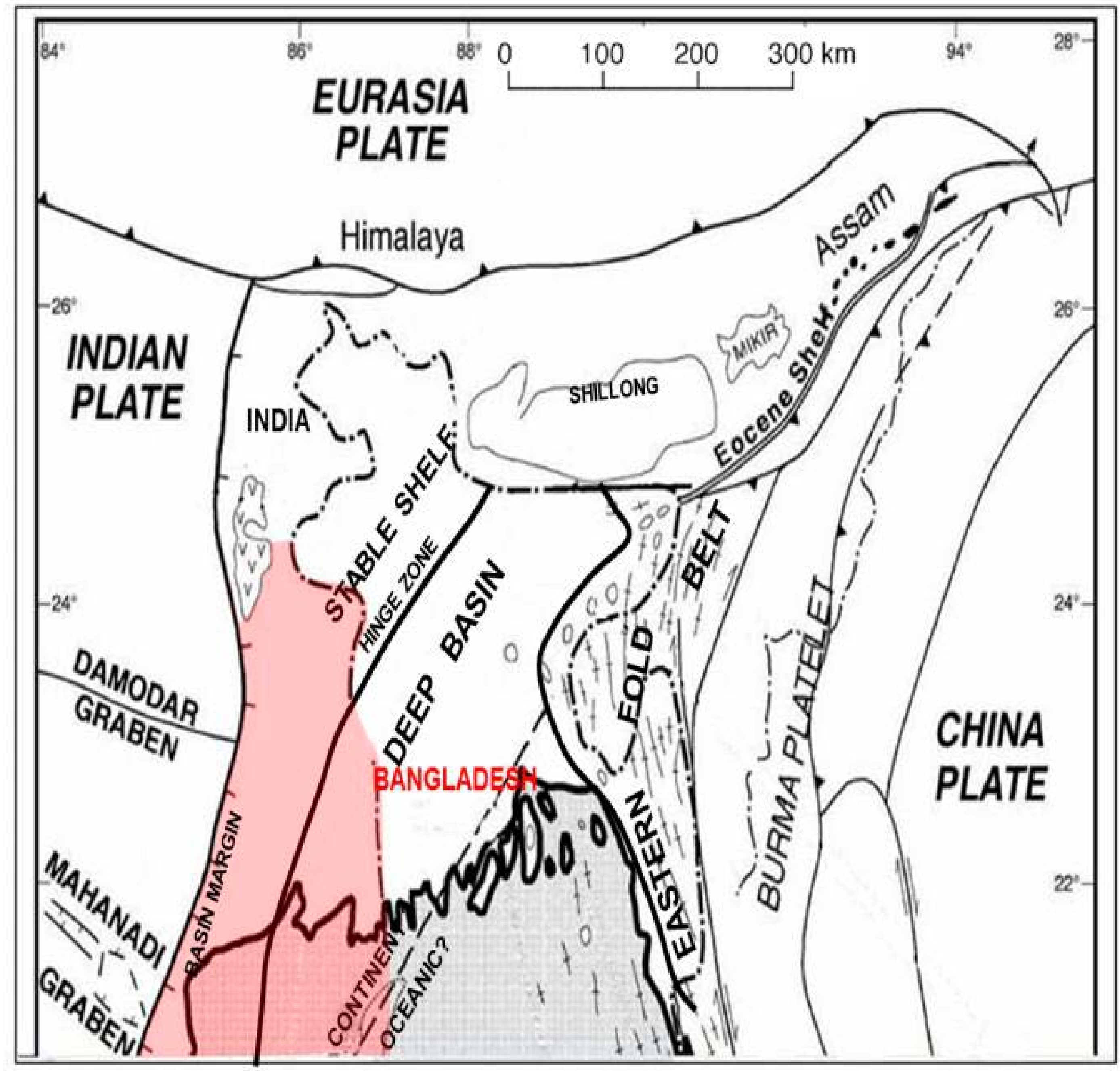

Figure 2. Tectonic map of Bengal Basin.

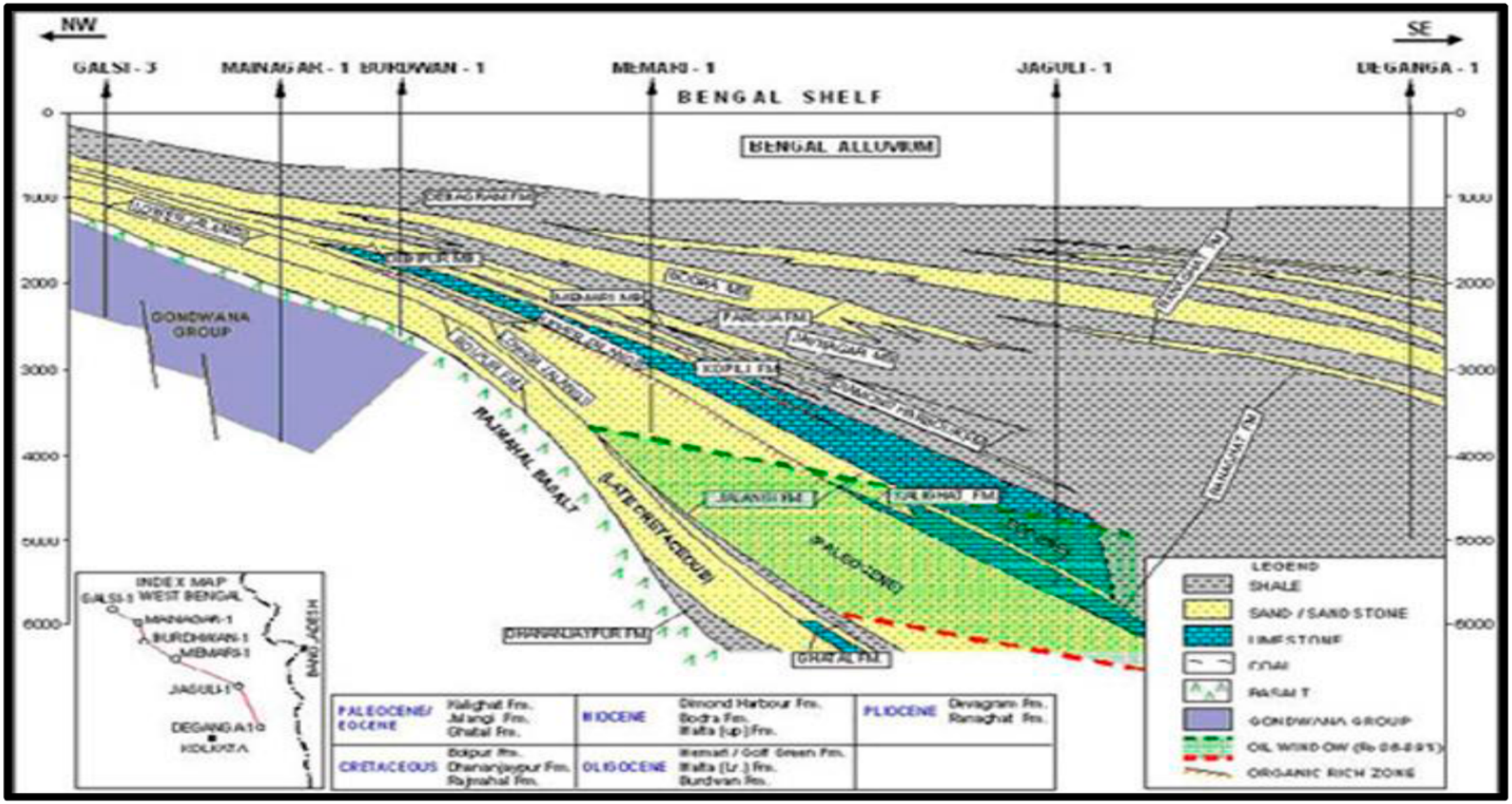

Figure 3. Regional Geological Cross Section across Bengal Basin.

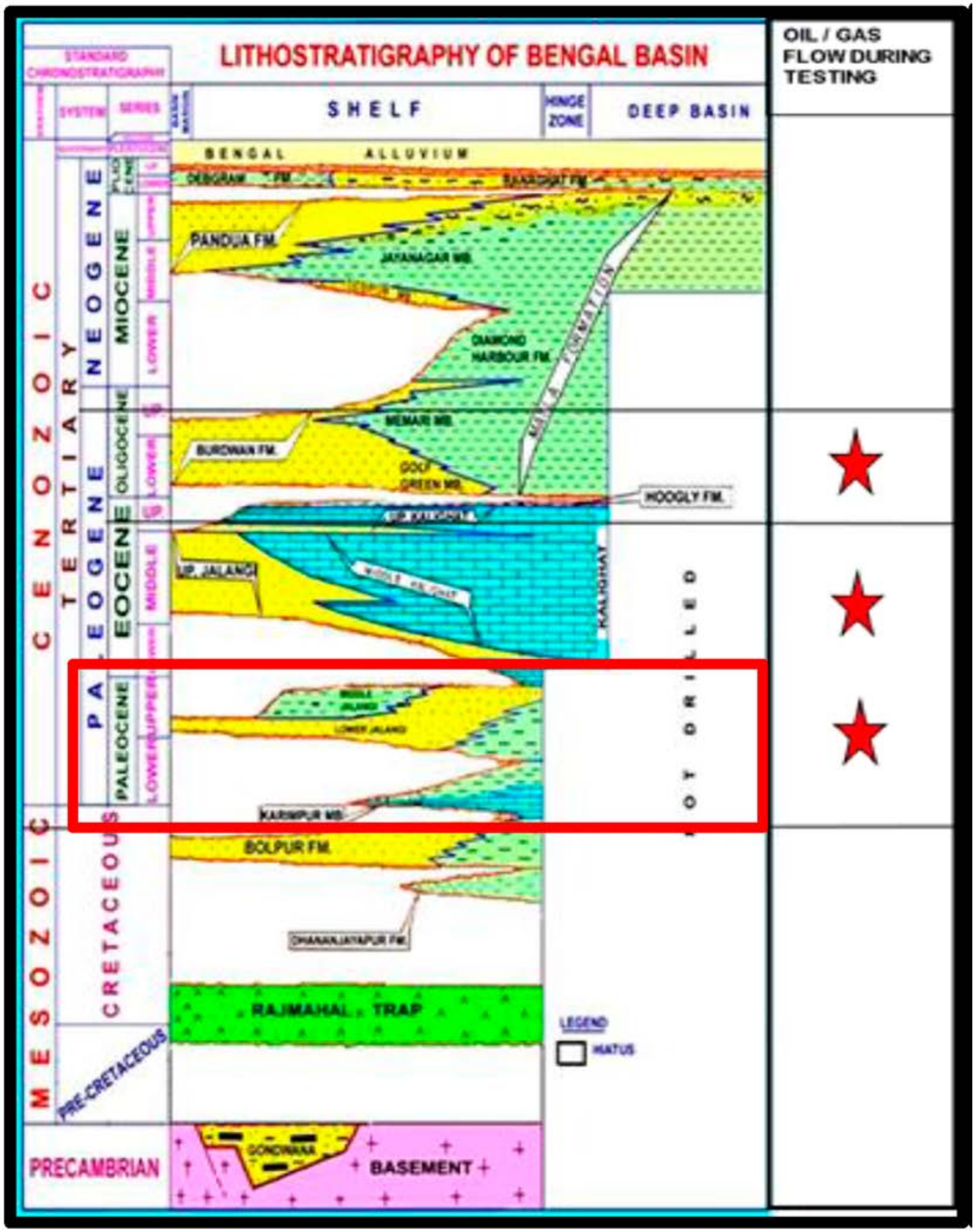

Figure 4. Generalised stratigraphy of Bengal Basin.

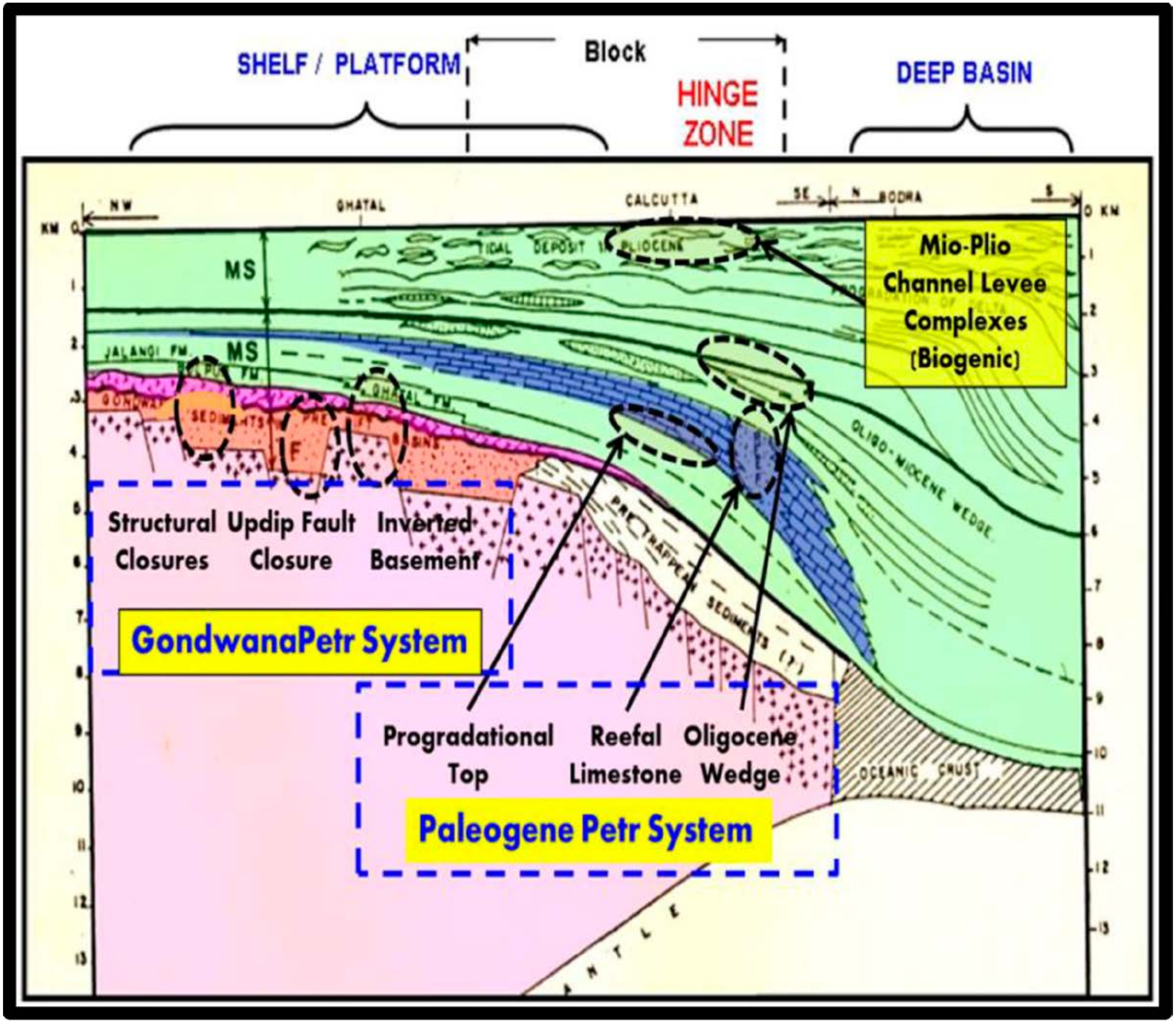

Figure 5. Existing Petroleum system of Bengal Basin.

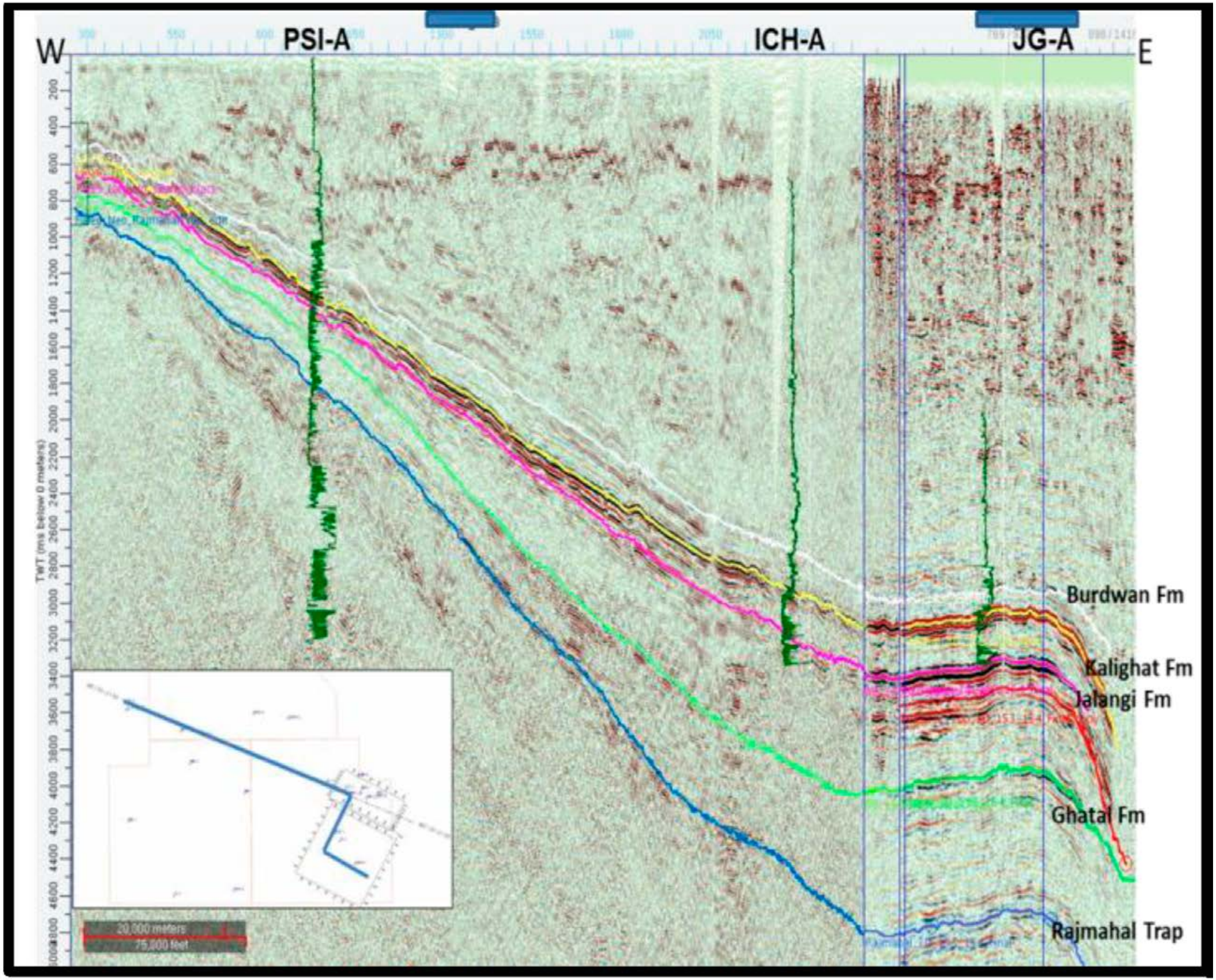

Figure 6. Regionally correlated horizons and markers.

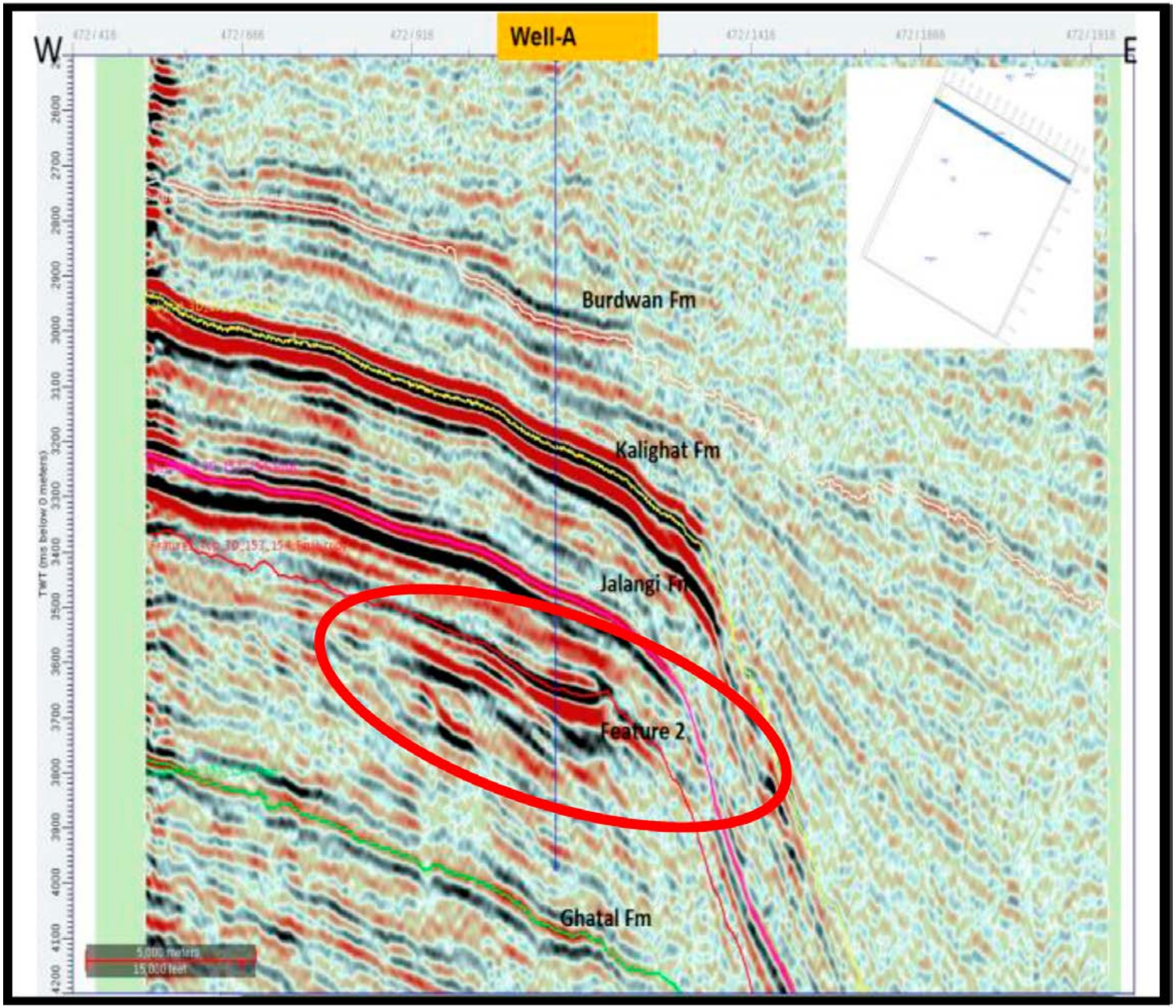

Figure 7. Zone of Interest on Seismic section.

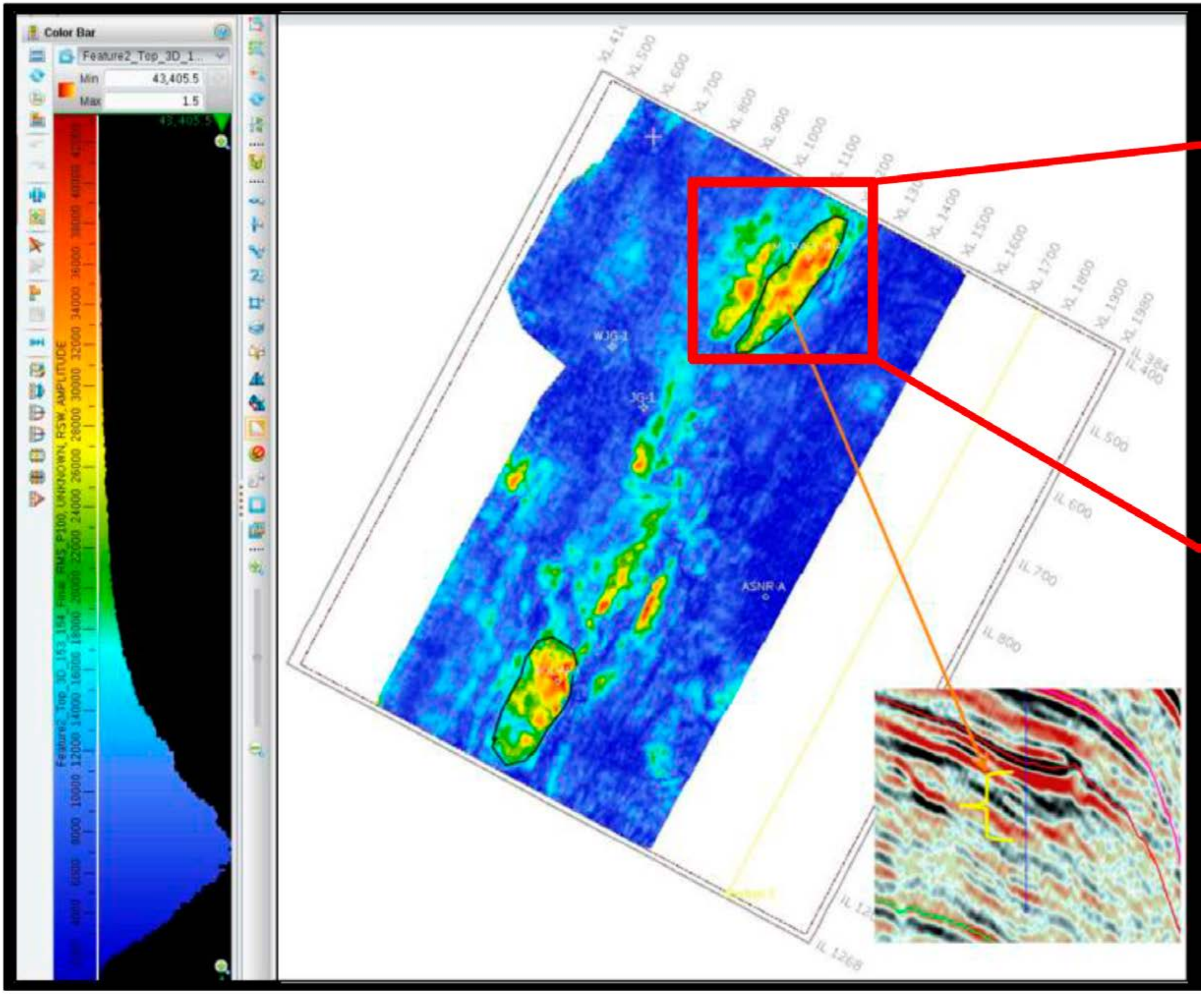

Figure 8. RMS amplitude attribute map corresponding to 100ms Window below Feature2_top Horizon showing high amplitude elongated features/geobodies aligned parallel or low angle with respect to the paleo coastline.

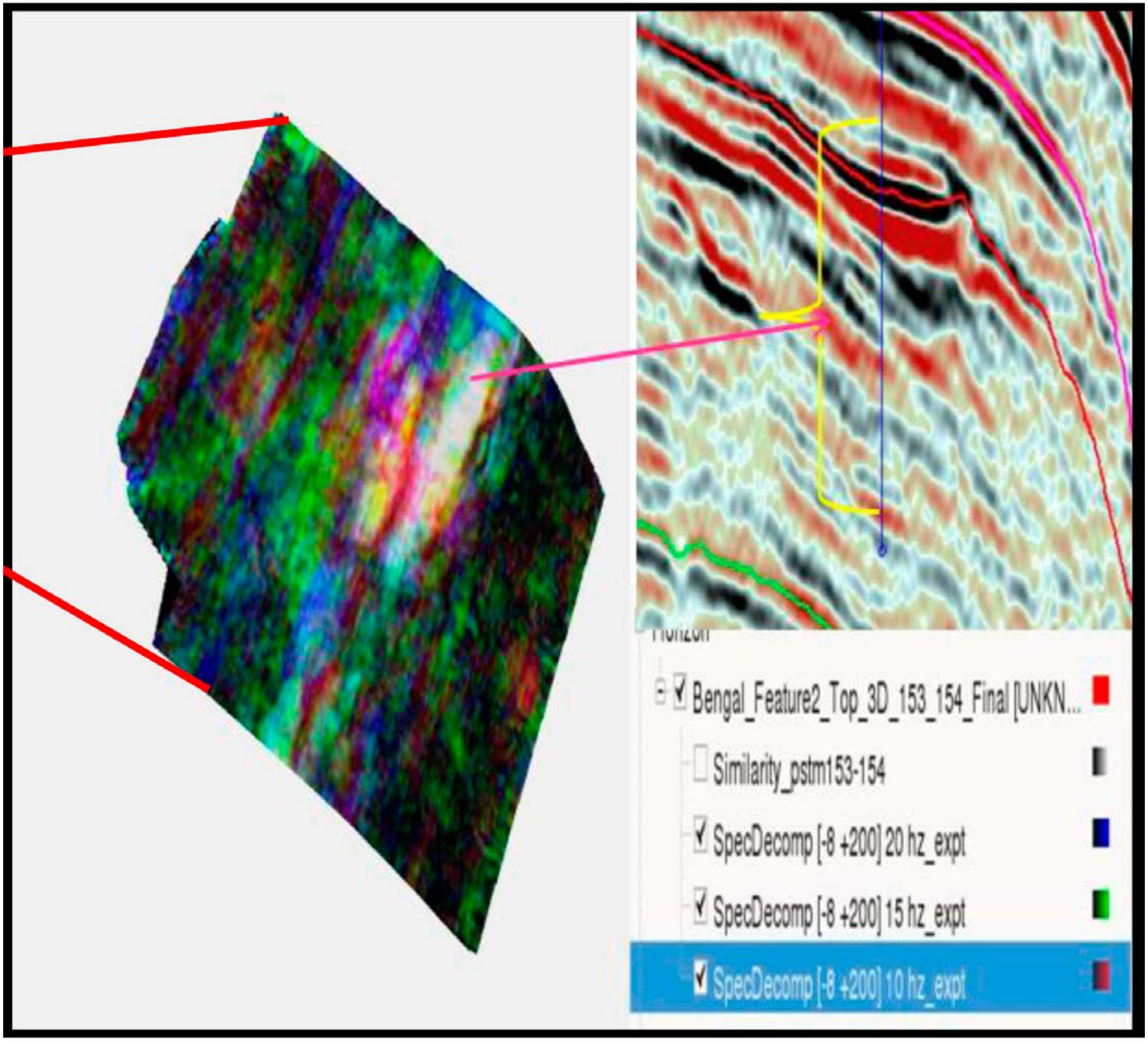

Figure 9. RGB Blending of the same geobody.

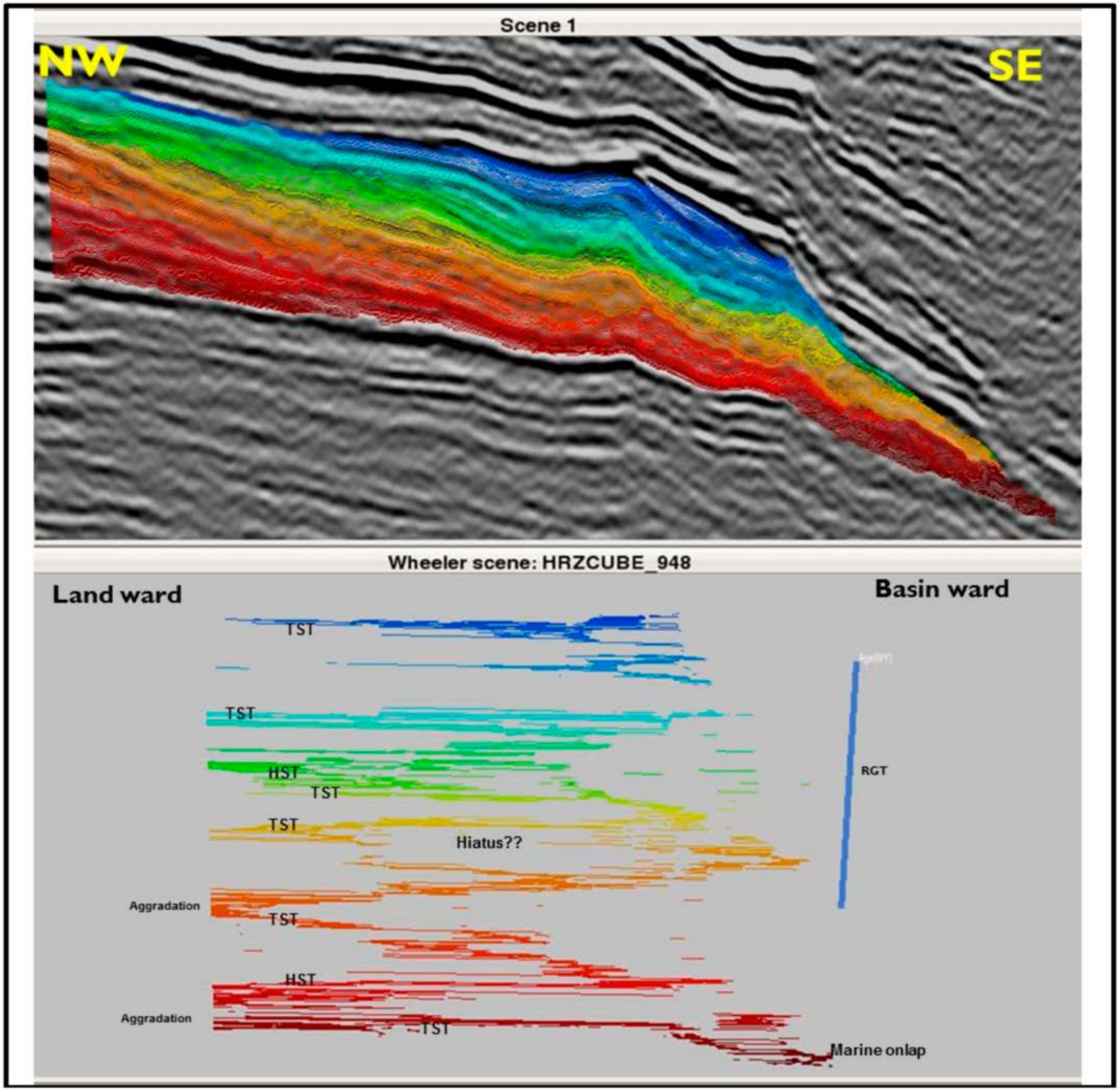

Figure 10. High-resolution Horizon Cube and Wheeler transform generated on IL948 in 3D volume.

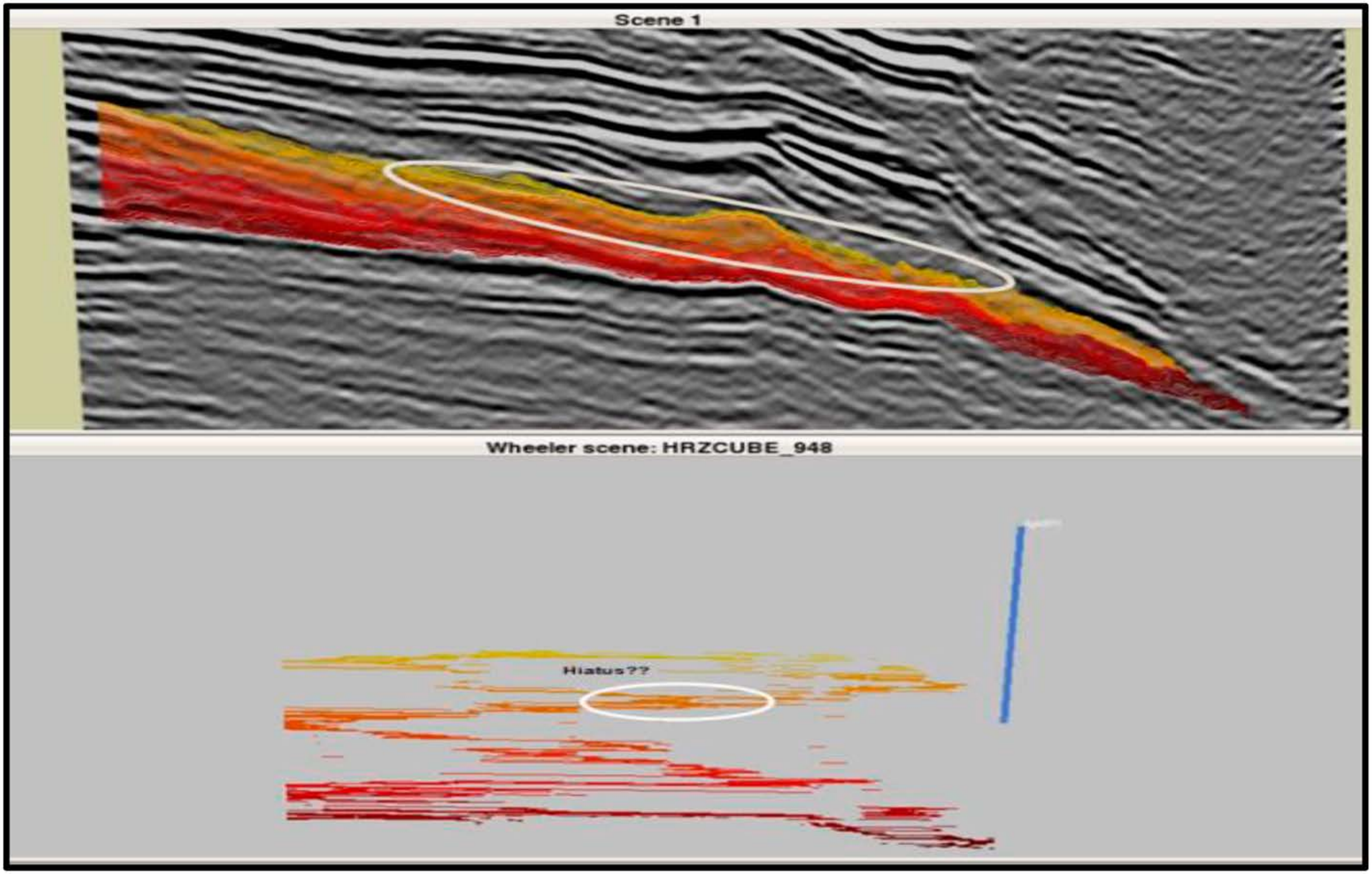

Figure 11. The feature within the elliptical circle is identified as an isolated body close to shelf edge.

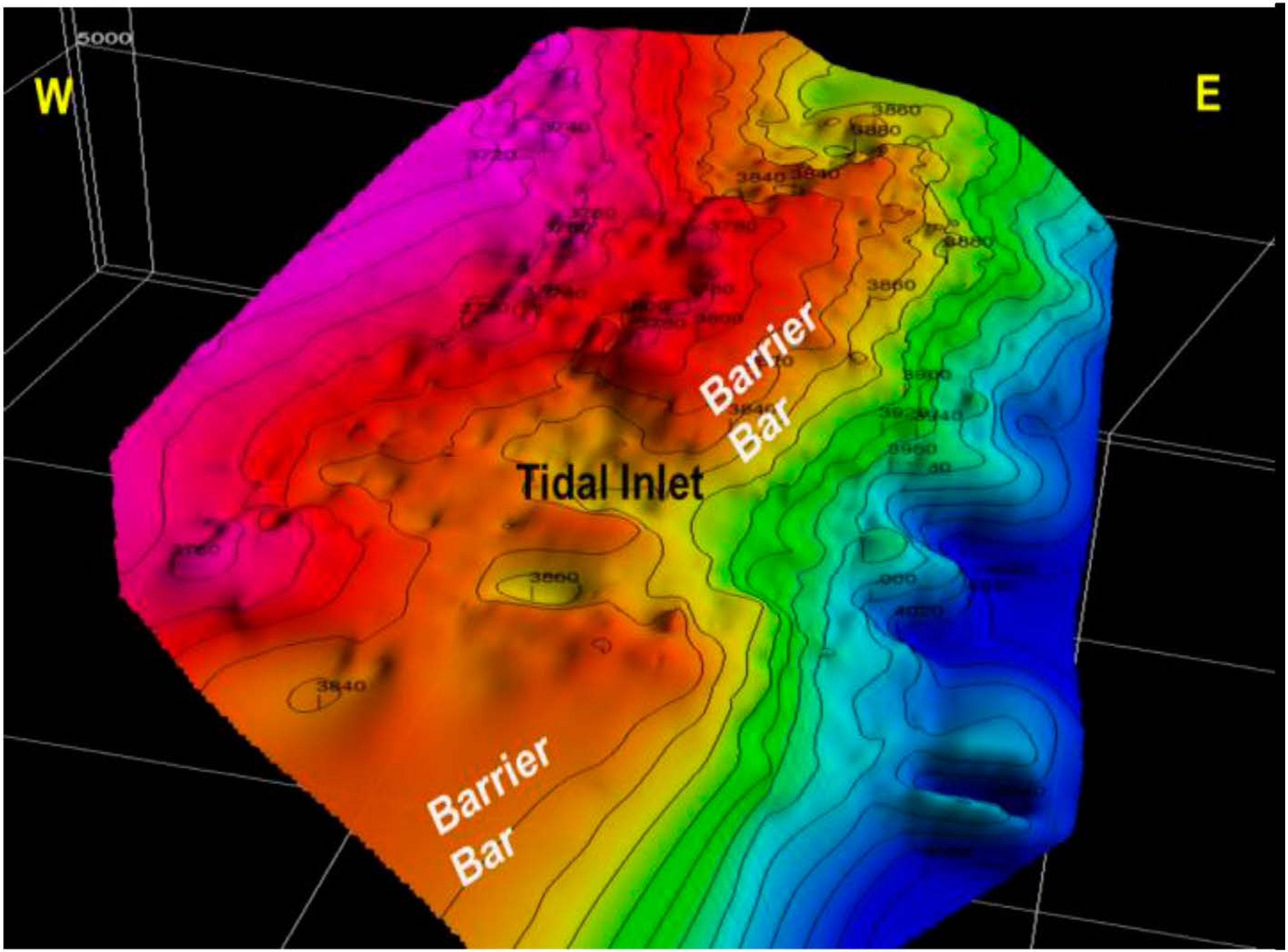

Figure 12. Map showing Barrier Bar and Tidal Inlet complex.

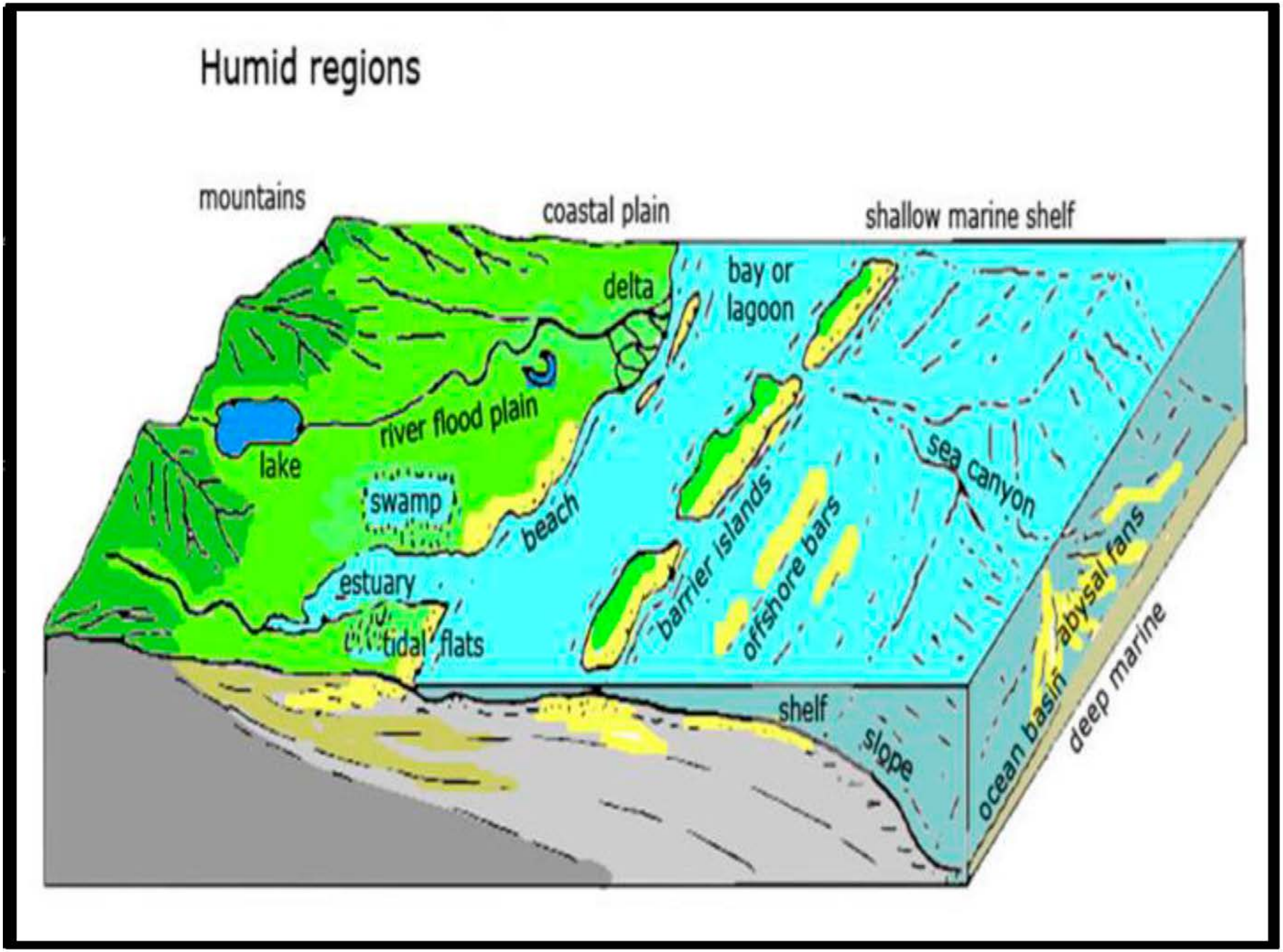

Figure 13. Clastic deposition in a Marginal Marine environment.

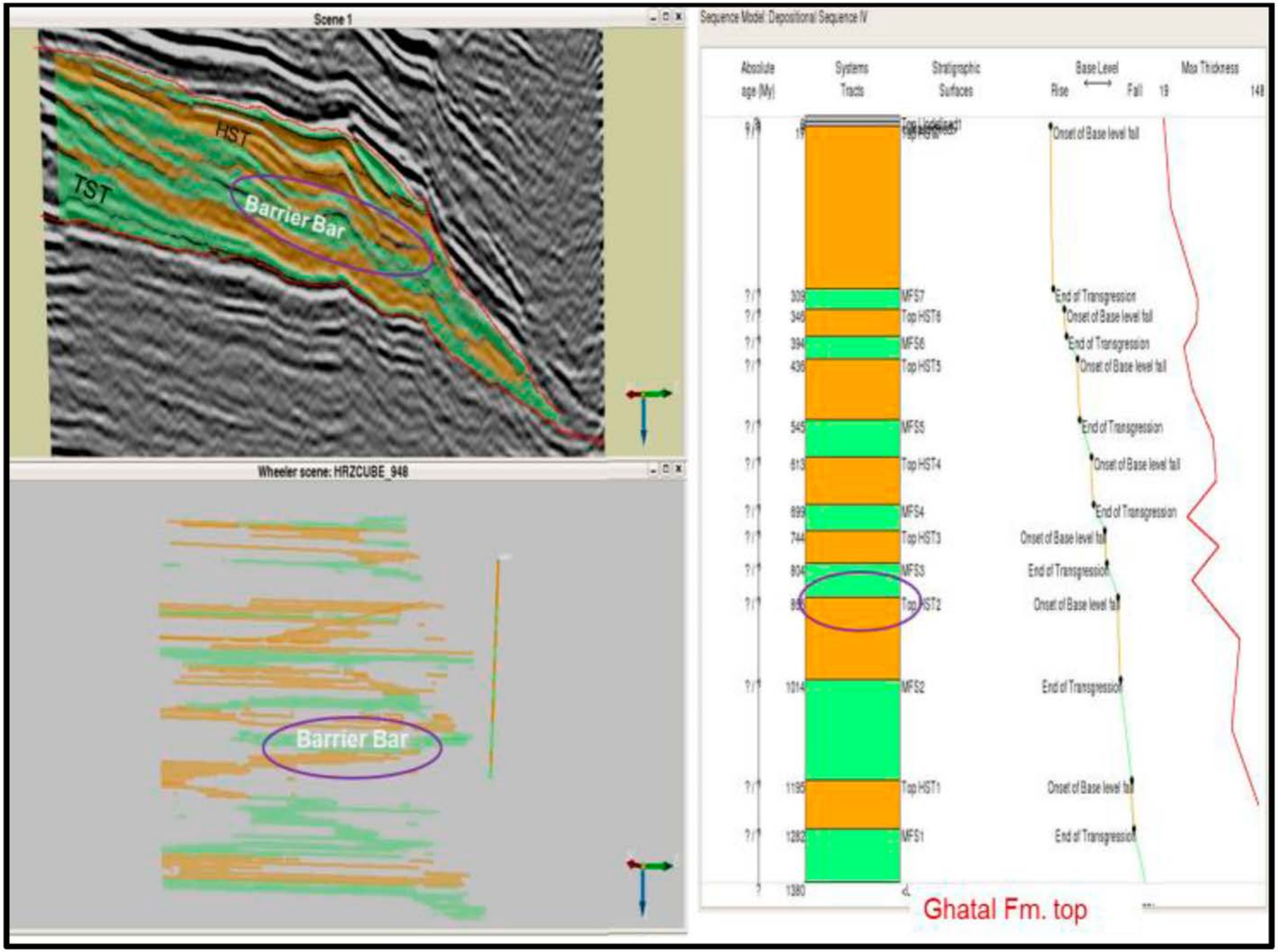

Figure 14. Systems Tracts Study on Seismic line (IL948).

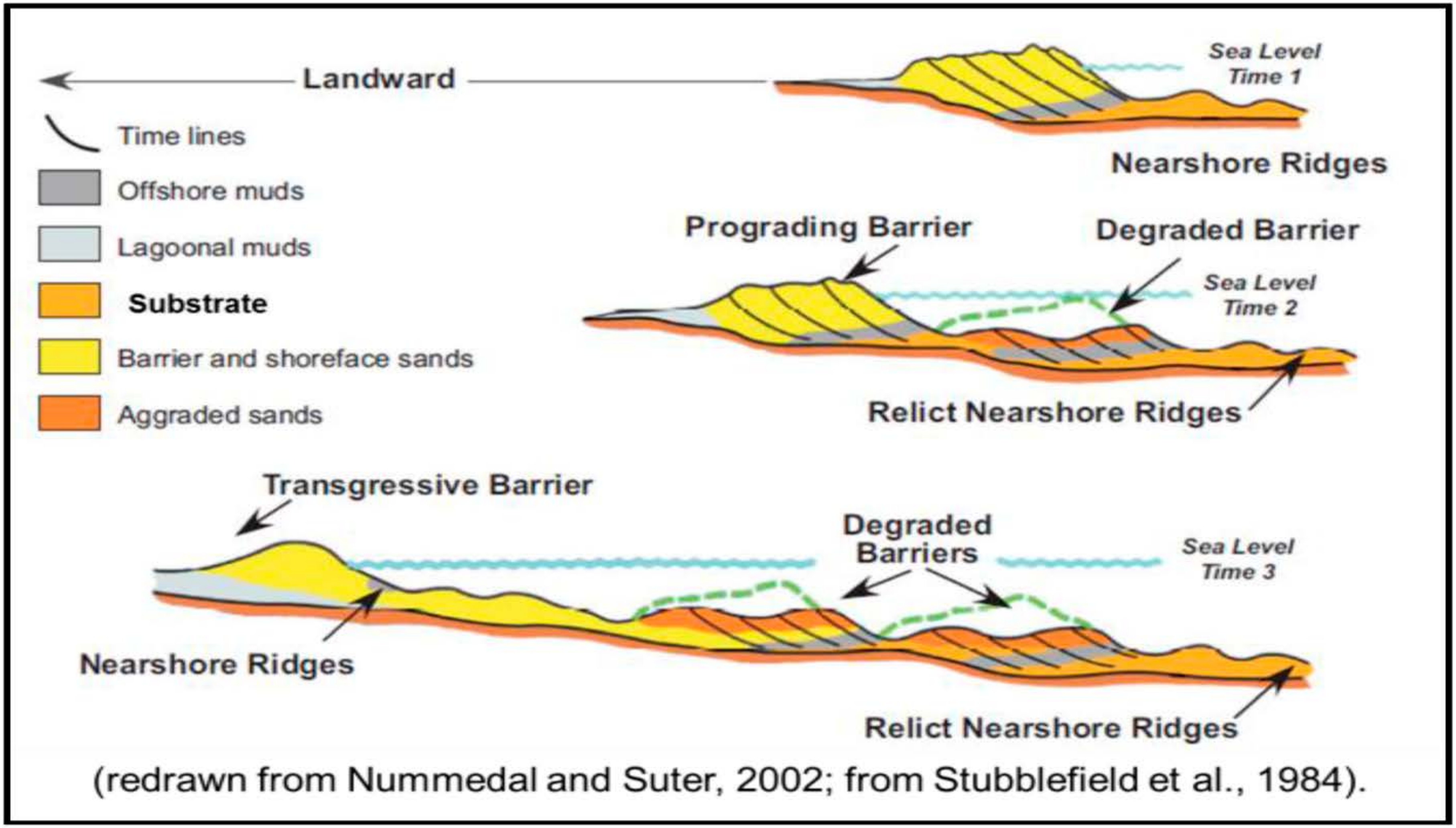

Figure 15. Model for Transgressive Barrier Bar complex.