Tectonic Controls on an Unconventional Sediment Transport Pathway Interpretation Used 3-D Seismic Data Analysis in Non-Marine Rift-Basin Setting: An Example from the Paleogene of Western Slope of Bozhong Sag, Bohai Bay, East China*

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Abstract

Bohai Bay basin is a classic non-marine rift-basin and an important hydrocarbon-bearing basin in East China. Due to lack of sufficient well data, the diversity of sediment transport pathway and their controlling deposits was analyzed using the recent 3-D seismic data in the western slope of Bozhong sag, Bohai Bay basin. Bozhong sag lies in the conjunction of Yingkou-Weifang section of Tanlu fault belt (ENE-NE) with Zhangjiakou-Penglai fault belt. The ENE orientation of the long axis of the sag sedimentation center shows that the sedimentation is mainly controlled by ENE strike-slip fault of continuous distribution. The result showed that structures within rift basins affect depositional patterns by creating sites of uplift and erosion, by controlling pathways of sediment transport, and by defining the accommodation space for sediment deposition and preservation. Three types of sediment transport pathway were discovered in Paleogene of the western slope of Bozhong sag, including sediment transport pathway of paleo-channel, fault trough and structural transfer zones. The deposits of study area were controlled mainly by fault trough sediment transport pathway derived from Shaleitian uplift. The fault trough embedded by the two main normal faults adjacent to each other in the continental lake basin is a special type of sediment transport pathway, which is developed in the ravine or trough in a fault system or between different fault systems. When the filling of sediments follows the same direction as the trend of the fault belt, the pathway and accommodation space will be provided by the trough for sediment transportation, deposition and preservation. This will lead to the formation of a series of axial gravity flow deposits, fan delta or alluvial fan-delta which are distributed parallel with the basin long axis and along with the fault strike.

Five terms of fault through were identified in the study area and their distribution directions are paralleled to fault zones strike in NEE direction. Compared to sediment transport pathway of paleo-channel, structural transfer zones, and longitudinal gravity currents sediment, fault trough was an unconventional sediment transport pathway in non-marine rift-basin setting. The types of fault through could be subdivided single fault trough with wedge shape external geometry form of seismic reflection and double fault trough with sheet shape external geometry form of seismic reflection. The seismic sections along the fault through strike showed the typical progradational seismic reflection. On the basis of the an integrated analysis of seismic multi-attributes, 3-D seismic geomorphology, sedimentary facies and sedimentary facies model, the deposits controlled by fault trough sediment transport pathway were the belted distribution in NEE direction, lying between parallel faults or fault zones, and their sedimentary facies boundary was recognized quantitatively.

The fault trough sediment transport pathway found in the Paleogene strata of western slope of Bozhong sag was believed to be strongly controlled by the tectonic evolution of the rift basin and may have important implications to basins with similar tectonic setting elsewhere.

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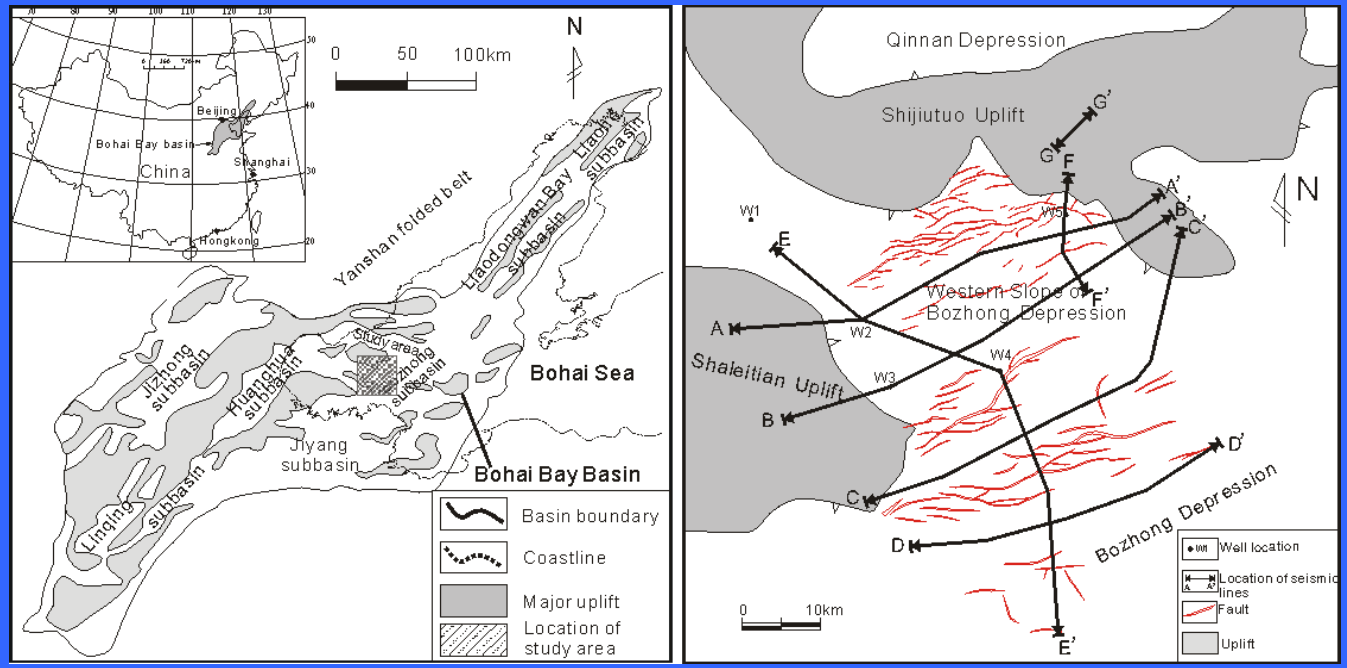
1.Introduction

Bohai Bay basin is a classic non-marine rift-basin and an important hydrocarbon-bearing basin in East China. Due to lack of sufficient well data, the diversity of sediment transport pathway and their controlling deposits was analyzed using the recent 3-D seismic data in the western slope of Bozhong sag, Bohai Bay Basin.



Map of the western slope of Bozhong sag, Bohai Bay Basin, showing distribution of faults and locations of wells, seismic cross sections.

1.Introduction

The result showed that three styles of sediment transport pathway were discovered in Paleogene of the western slope of Bozhong sag, including sediment transport pathway of paleo-channel, faulted trough and structural transfer zones. The deposits of study area were mainly controlled by the sediment transport pathway of faulted trough derived from Shaleitian Uplift. Five terms of faulted through were identified in the study area and their distribution directions are paralleled to fault zones strike in ENE direction.

1.Introduction

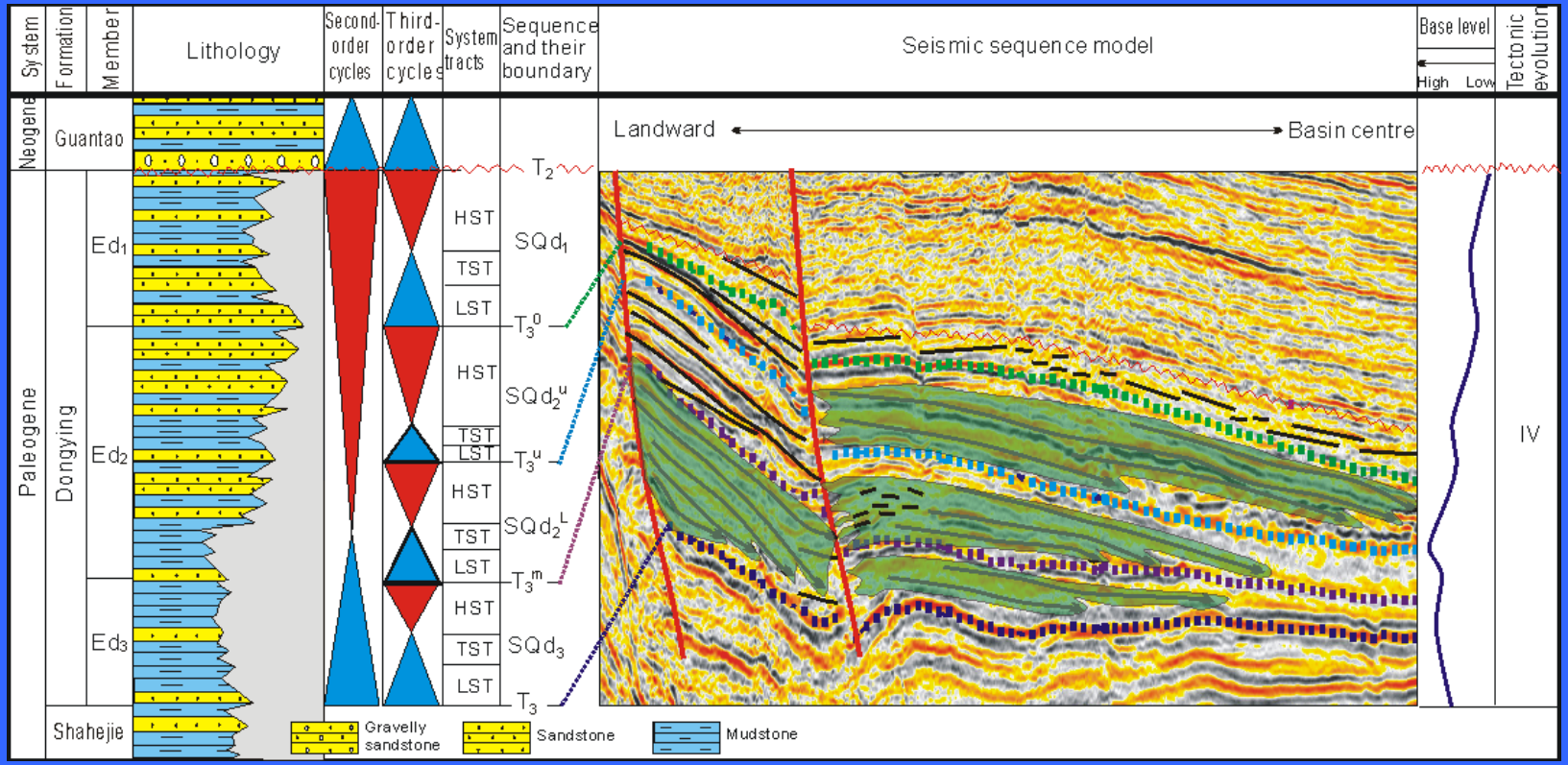
Compared to sediment transport pathway of paleo-channel, structural transfer zones, and longitudinal gravity currents sediment, faulted trough was an unconventional sediment transport pathway in non-marine rift-basin setting. The styles of faulted through could be subdivided single faulted trough with wedge-shape external geometry form and double faulted trough with sheet-shape external geometry form. The seismic sections along the faulted through strike showed the typical progradational seismic reflection.

1.Introduction

On the basis of the an integrated analysis of seismic multi-attributes, 3-D seismic geomorphology, depositional facies and its model, the deposits controlled by the sediment transport pathway of faulted trough were the belted distribution in ENE direction, lying between parallel faults or fault zones, and their depositional facies boundaries were recognized quantitatively.

2. Sequence stratigraphic framework

The second-order sequence of the Dongying Formation can be further subdivided into four third-order sequences, namely SQd_3, SQd_2^L , SQd_2^u, and SQd_1 from bottom to top.

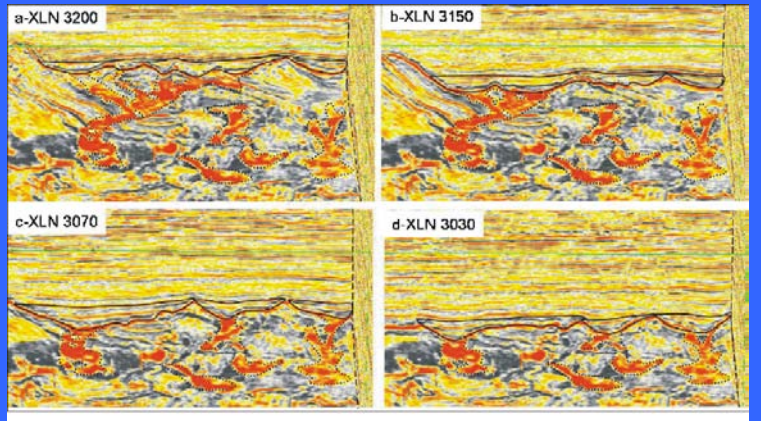


Generalised stratigraphic column and tectonic evolution in the Dongying formation of study area.

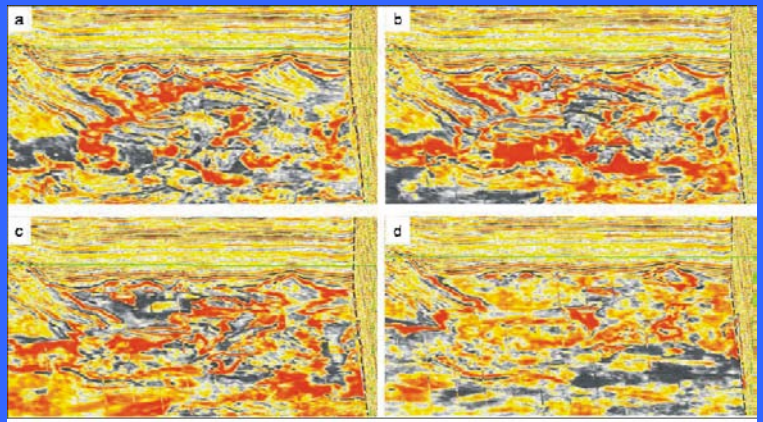
3. conventional sediment transport pathway of paleo-channel

Paleo-channel	Infilling style	Seismic reflection
V shape geometry		
U shape geometry	Vertical stack	
	Lateral stack	
W shape geometry		
Combined shape geometry		

Styles of paleo-channel of the Dongying formation of study area.

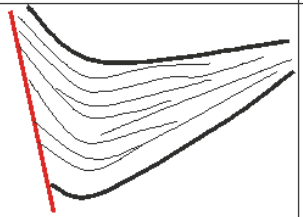
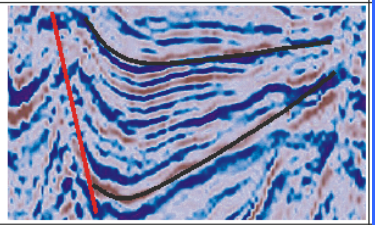
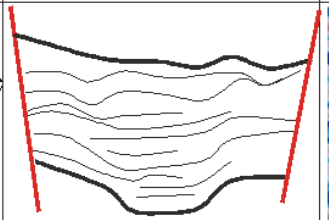
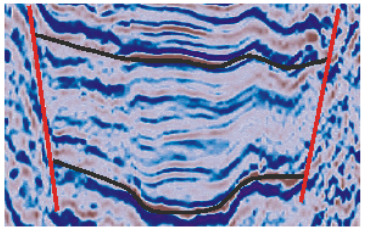
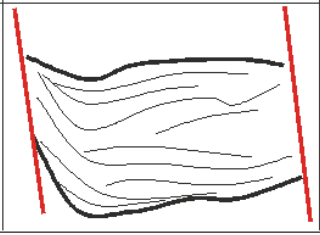
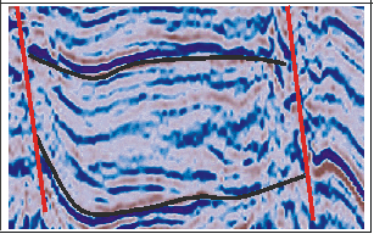


Seismic cross section 3200-3030 of Shijiutuo uplift showing 3D spatial characteristics of paleo-channel in study area.



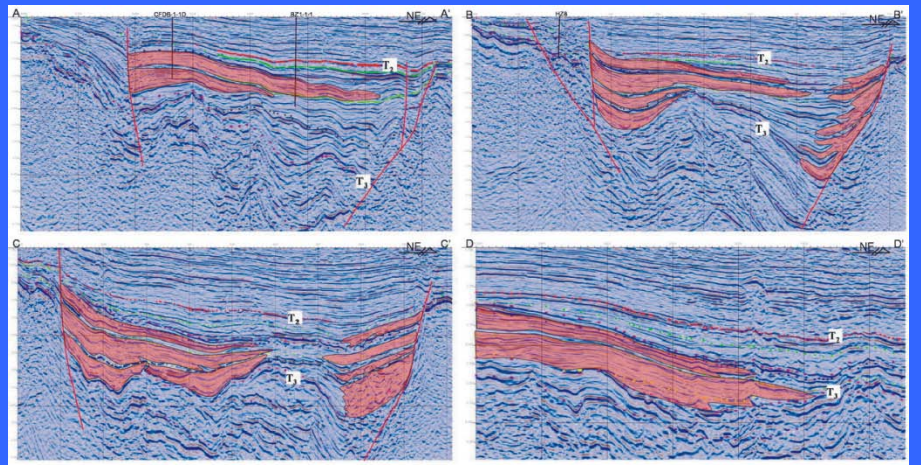
Stratal slice showing 3D characteristics of different stage of paleo-channel in study area.

4. unconventional sediment transport pathway of faulted trough

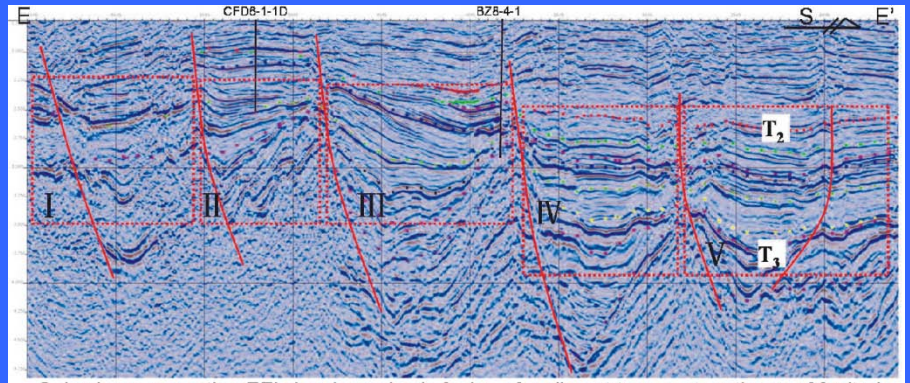
Faulted trough	Infilling style	Seismic reflection
Singal-faulted trough		
Antithetic faulted trough		
synthetic faulted trough		

Singal-faulted trough= sediment transpoert pathway controlled by one normal fault forming half graben.
Antithetic-faulted trough = sediment transpoert pathway controlled by antithetic faults.
Synthetic-faulted trough = sediment transpoert pathway controlled by synthetic faults.

Styles and seismic facies of sediment transport pathway of faulted trough, western slope of Bozhong sag.

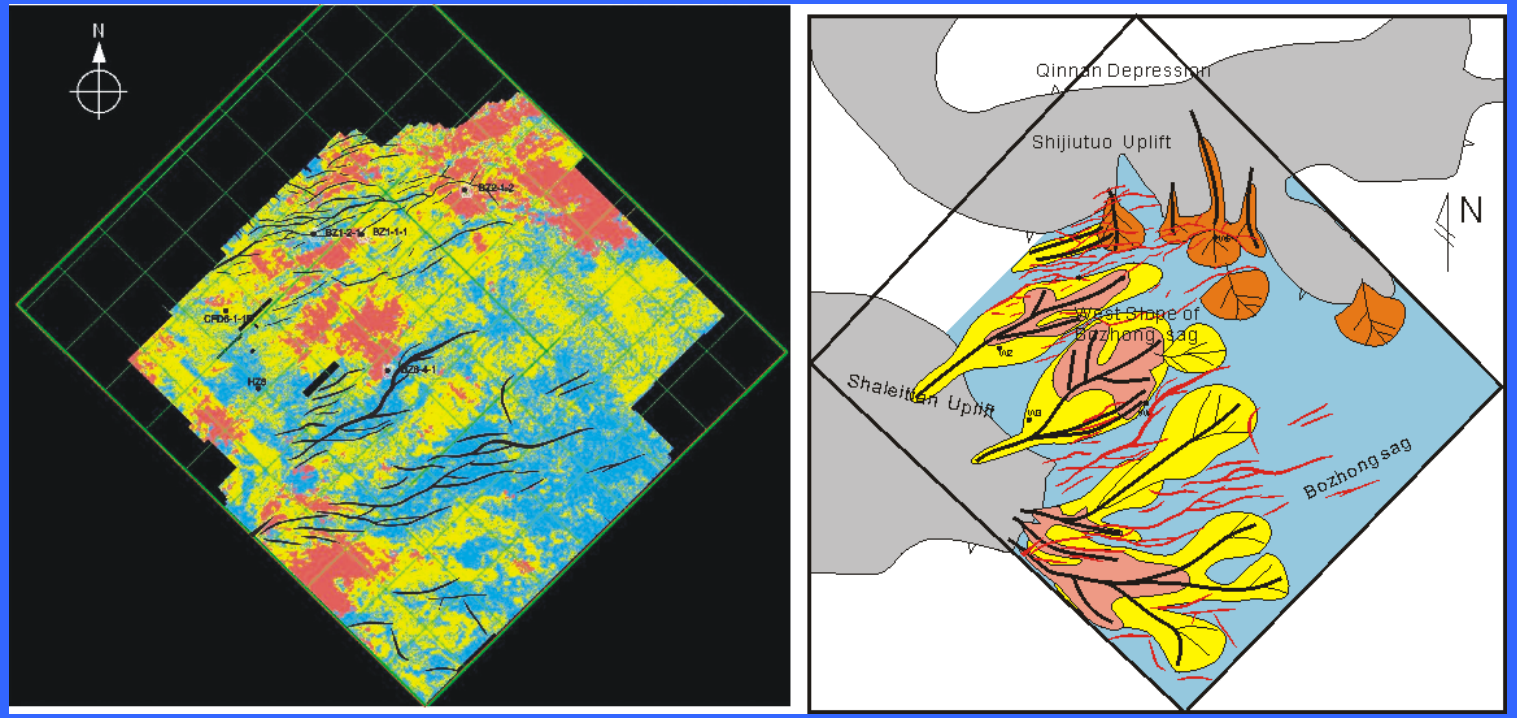


Seismic cross section AA'~DD' showing progradational seismic facies of sediment transport pathway of faulted trough along sediment transport direction, in NEE direction, western slope of Bozhong sag. See Fig. 1 for the location of the cross-section.



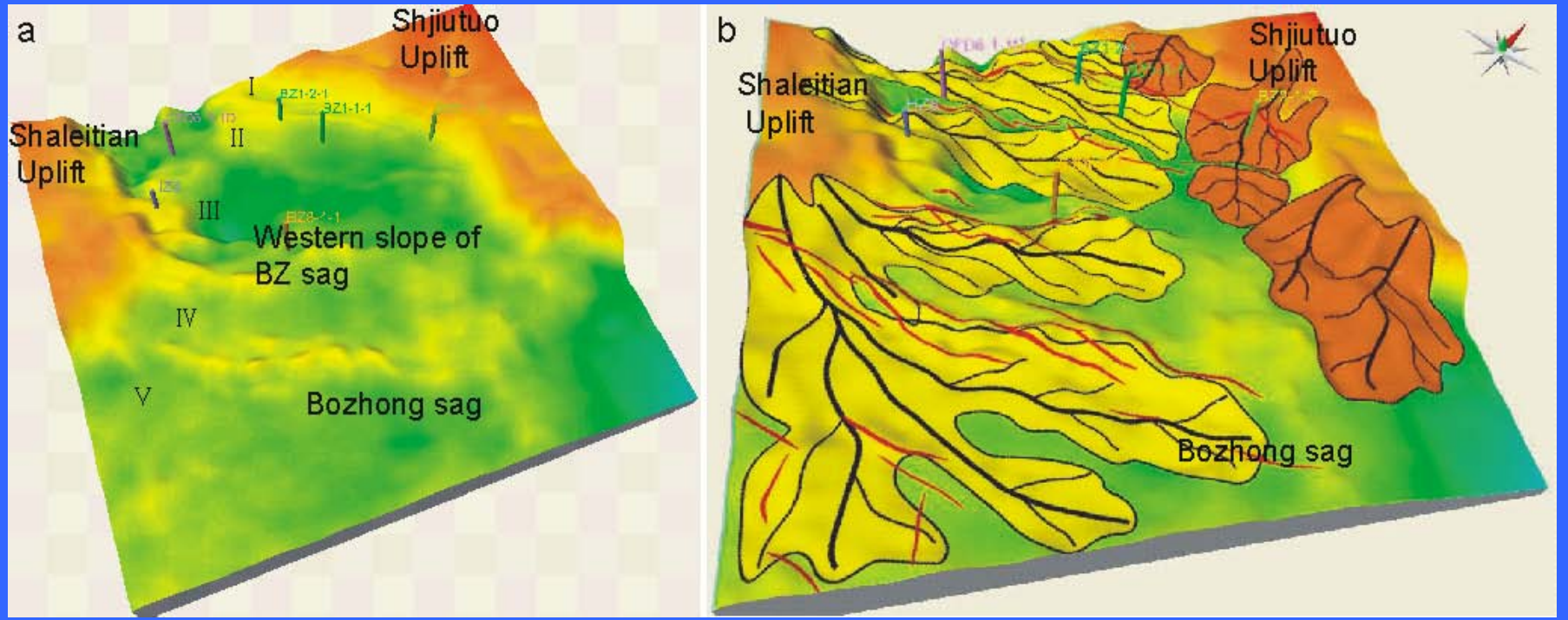
Seismic cross section EE' showing seismic facies of sediment transport pathway of faulted trough perpendicular to sediment transport direction, in N-S direction, western slope of Bozhong sag. See Fig. 1 for the location of the cross-section.

5. The planar distribution of sediment transport pathway of faulted trough



Seismic multi-attributes and depositional facies showing belted distribution of sediment transport pathway of faulted trough, Dongying Formation, western slope of Bozhong sag.

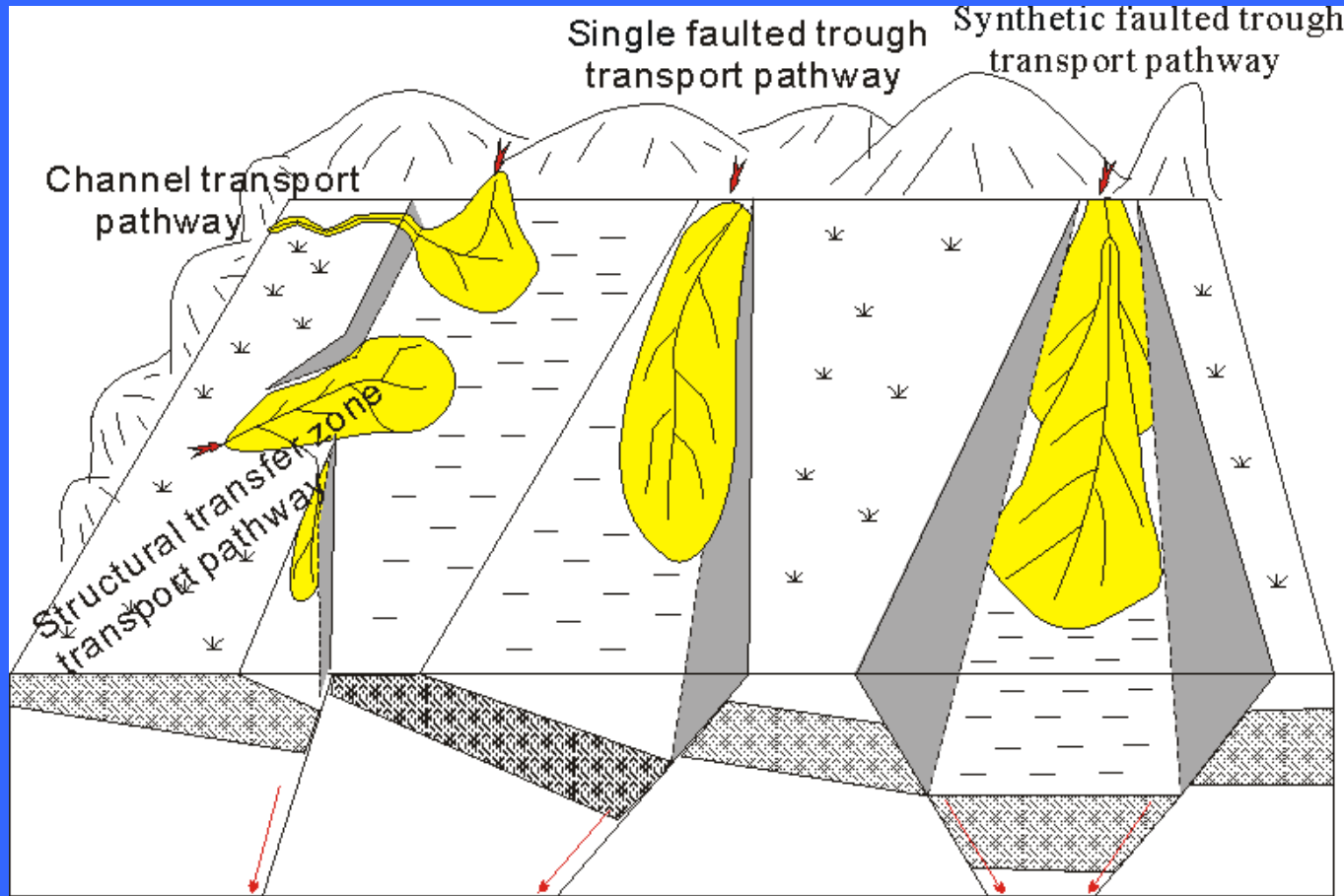
5. The planar distribution of sediment transport pathway of faulted trough



Paleo-geography and sedimentary model showing belted distribution of sediment transport pathway of faulted trough of Paleogene, western slope of Bozhong sag.

6. A conceptual model of sediment transport pathway for the typical continental lacustrine basins

A conceptual model of sediment transport pathway from the source area to the sedimentary area for the typical continental lacustrine basins, shown sediment transport pathway controlled by faulted trough, paleo-channel, and structural transfer zone.



7. Conclusion

The Paleogene deposits in the western slope of Bozhong sag in Bohai Bay Basin were mainly sourced from Shaleitian Uplift and controlled by the unconventional sediment transport pathway of faulted trough. Whereas the deposits sourced from Shijiutuo Uplift were controlled by paleo-channel and distributed locally in the southern Shijiutuo uplift.

7. Conclusion

The successful case study is facilitated by using 3-D seismic data to analyze sediment transport pathway. This study reveals that the Paleogene sediments sourced from Shaleitian Uplift in western slope of Bozhong sag is mainly transported by the pathway of faulted trough. This changed the conventional viewpoint that the alluvial fan and fan-delta systems were distributed closely to the east of Shaleitian uplift and the sediments were transported in short distance. The new depositional model is useful for predicting reservoirs.

Thank you for your attention!

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