

# **Application of Seismic Sedimentology in Prediction of Cretaceous Lacustrine Beach and Bar Sandstone: A Case Study in Chepaizi Area, Junggar Basin, NW China\***

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## **Abstract**

Seismic sedimentology is a newly emerged interdisciplinary subject, which uses seismic data to gain insights into the rocks and their forming processes. It is regarded as a very effective tool for mapping high-frequency sequence and depositional systems, and plays an important role in the exploration and production of thin sandstone reservoirs. This study is aimed at predicting the distribution of beach and bar sandstone reservoirs in Chepaizi area by seismic sedimentological studying.

The Cretaceous sediments in the Chepaizi area, located in the northwestern margin of Junggar Basin, northwest China, were mainly deposited shore-shallow lacustrine beach bar microfacies, which are characterized by thin single sand layer (usually 2-5m), fast lateral pinchout and strong reservoir heterogeneity. These beach-bar sandbodies are NE-extended, usually 5-10km long and 2-3km wide. Most of them are oil-bearing, and vertical superimposed, constituting the main production reservoirs of Cretaceous. There is a great amount of high-quality 3D seismic data in Chepaizi area where faults are not developed. In this study, under the guidance of seismic sedimentary theory, and by making use of the 90° phase shift technique, frequency spectrum decomposition and stratal slicing, the sliced cubes were processed to display the distribution of sedimentary microfacies and reflect the evolutionary history. With the assistance of the comprehensive analysis of core, lithology and well-logging data, the beach-bar sandbodies of the typical slices were interpreted subtly, and the distribution and evolution of beach-bar microfacies were predicted. This study was approached by following procedures: well-to-seismic tie, wavelet-phase adjustment, picking of geologic-time parallel seismic events, seismic resolution analysis, petrophysical analysis, selection of seismic attributes, stratal slicing, seismic depositional facies analysis, and applications to exploration and development. The whole workflow emphasized the integration of seismic and geologic interpretations and balanced use of seismic sedimentology, sequence stratigraphy and seismic stratigraphy.

In light of this study, the beach bar sandstone reservoirs of different sequences were effectively predicted. It was found the formation of these beach and bars was primarily controlled by the integrated effects of many factors, such as source type, source supply, hydrodynamic condition and so on. Meanwhile, based on the detailed analysis of sedimentary characteristics and seismic sedimentary results, this study established two typical beach and bar sedimentary systems in Chepaizi area, normal bedrock-beach bar and fan delta-beach bar. Overall, this study provided a

reliable approach in exploration of subtle reservoirs in lacustrine environments and can serve as a reference for seismic sedimentology study in non-marine basins, especially in areas where detailed seismic work has been extensively done but few wells drilled.

### **Selected References**

Davies, R.J., (ed.), 2007, Seismic geomorphology: applications to hydrocarbon exploration and production: Geological Society of London, 274 p.

Embry, A.F., 1993, Transgressive-regressive (T-R) sequence analysis of the Jurassic succession of the Sverdrup Basin, Canadian Arctic Archipelago: Canadian Journal of Earth Sciences, v. 30/2, p. 301-320.

Zeng, H., S.C. Henry, and J.P. Riola, 1998, Strata slicing; Part II, Real 3-D seismic data: Geophysics, v. 63/2, p. 514-522.

## Application of Seismic Sedimentology in Prediction of Cretaceous Lacustrine Beach and Bar Sandstone: A Case Study in Chepaizi Area, Junggar Basin, NW China

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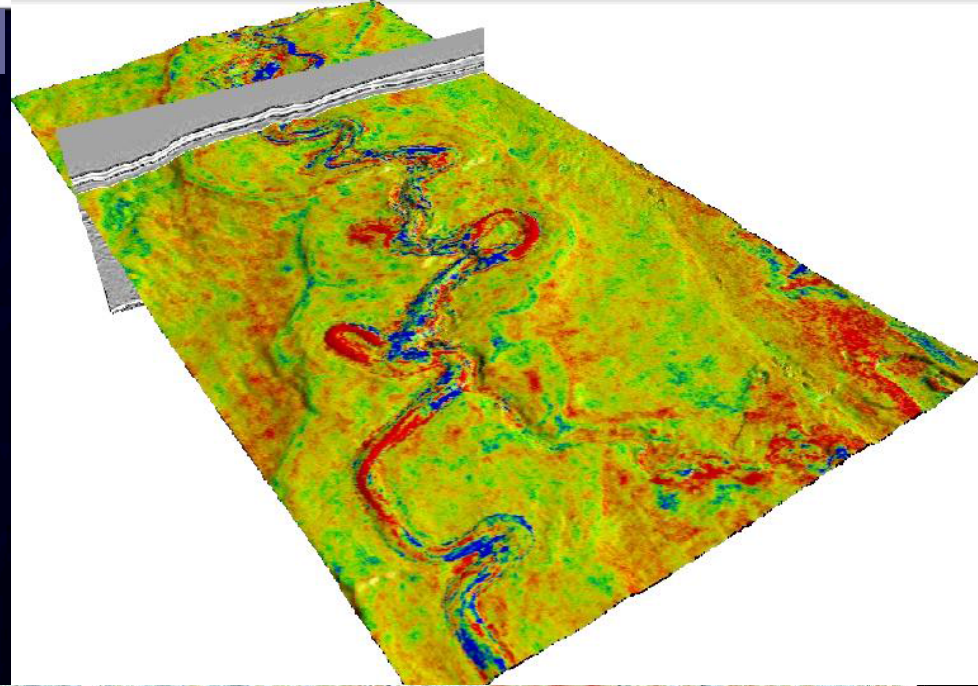
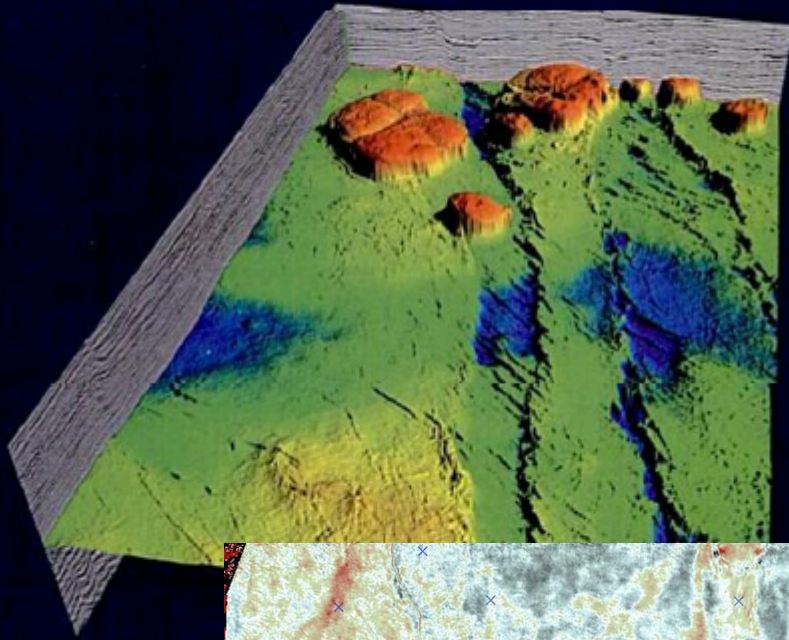


# Outline

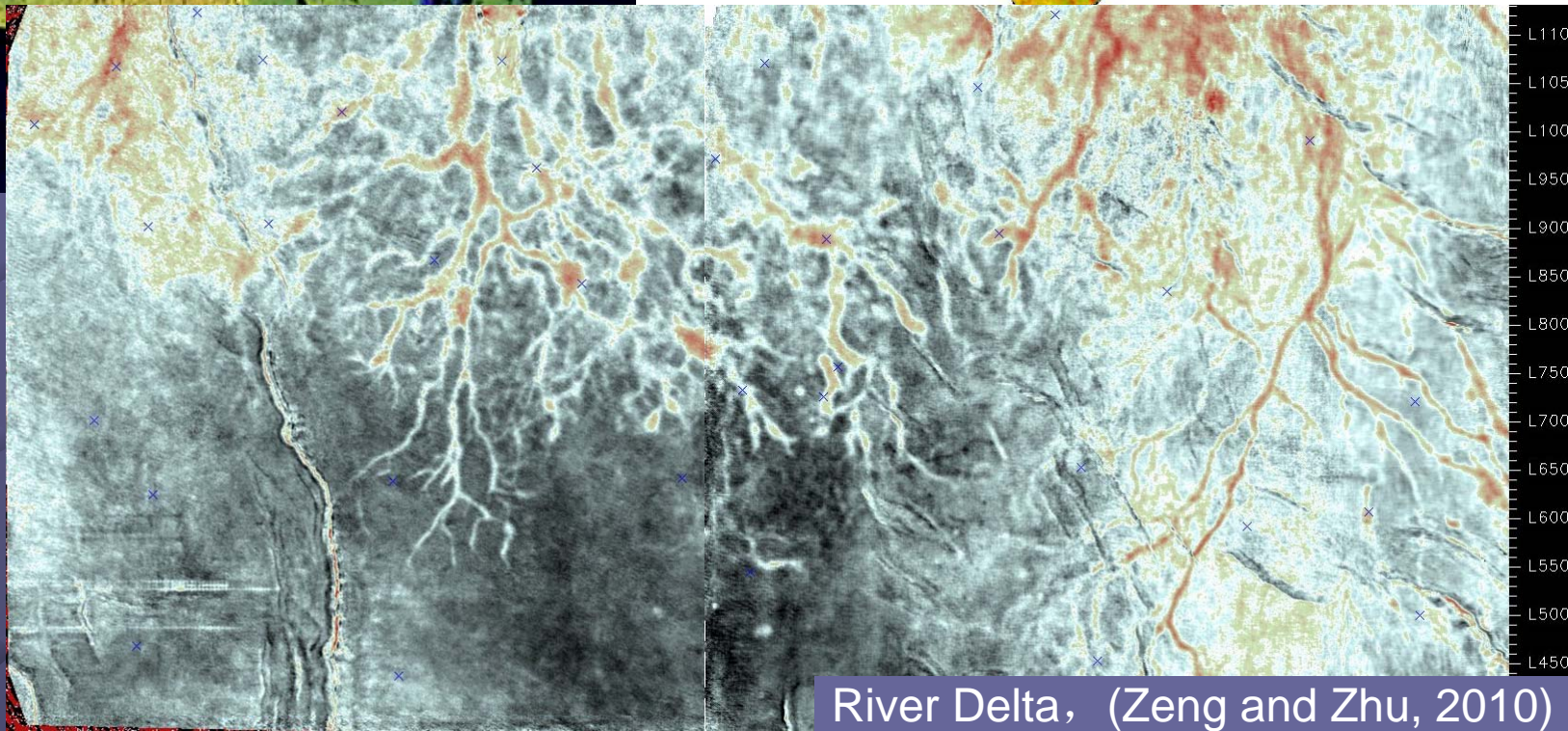
- Introduction
- Sequence Stratigraphy
- Seismic Sedimentology Study
- Analysis
- Conclusions



Reef



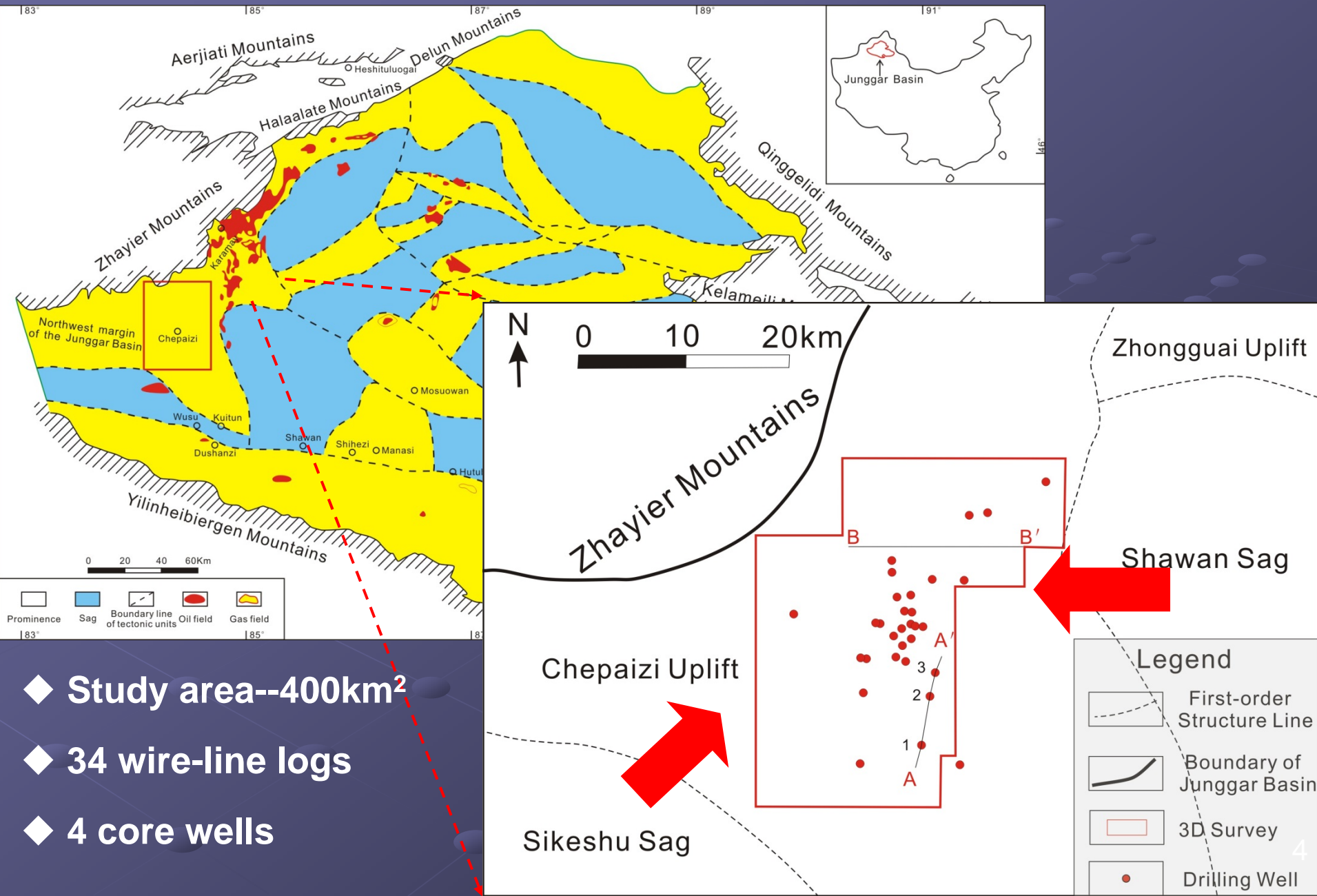
# Seismic Sedimentology



River Delta, (Zeng and Zhu, 2010)



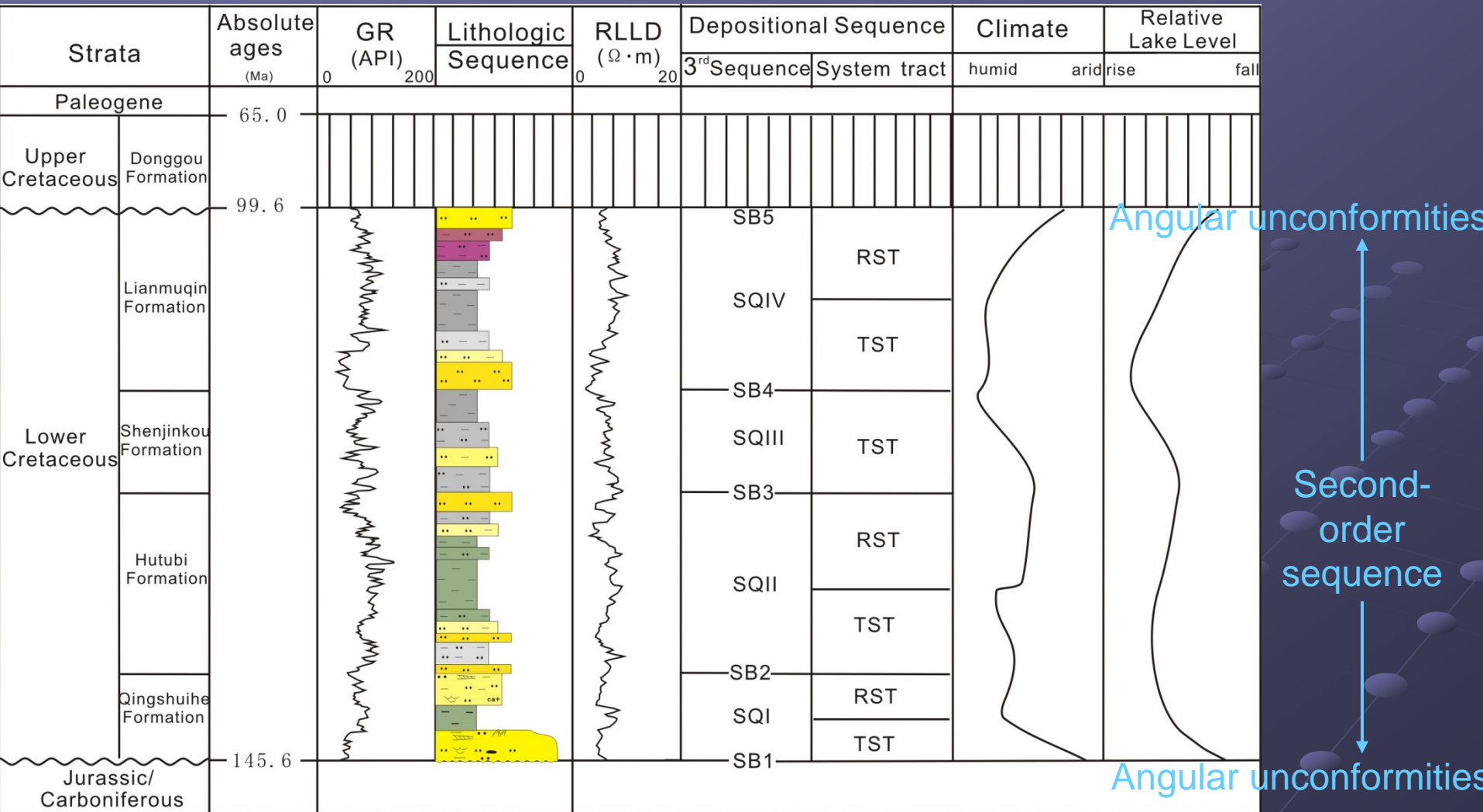
# Regional Setting



# Outline

- Introduction
- Sequence Stratigraphy
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# Sequence Stratigraphy

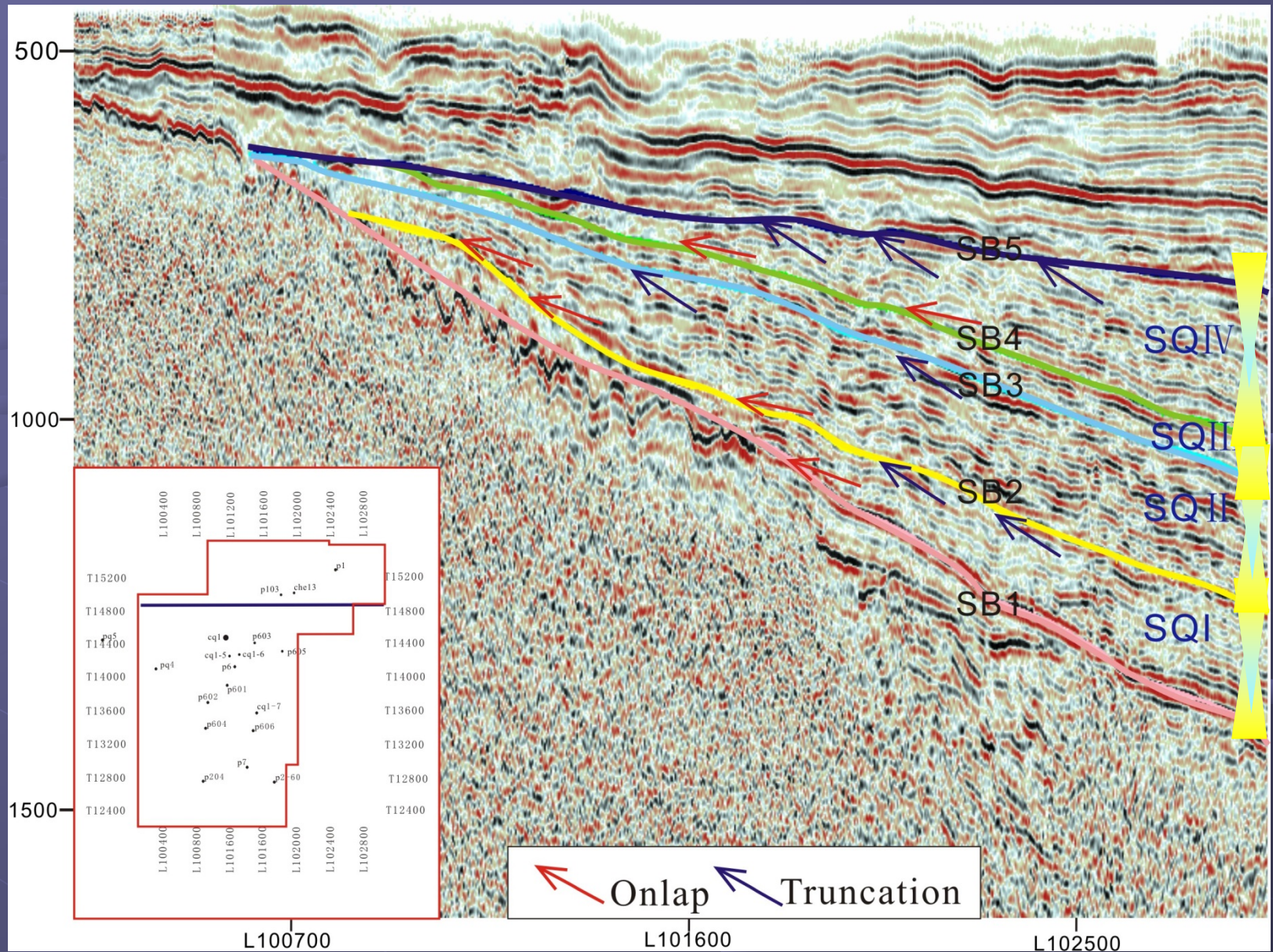


**Transgressive-Regressive (T-R) sequence model**

proposed by Embry, 1993



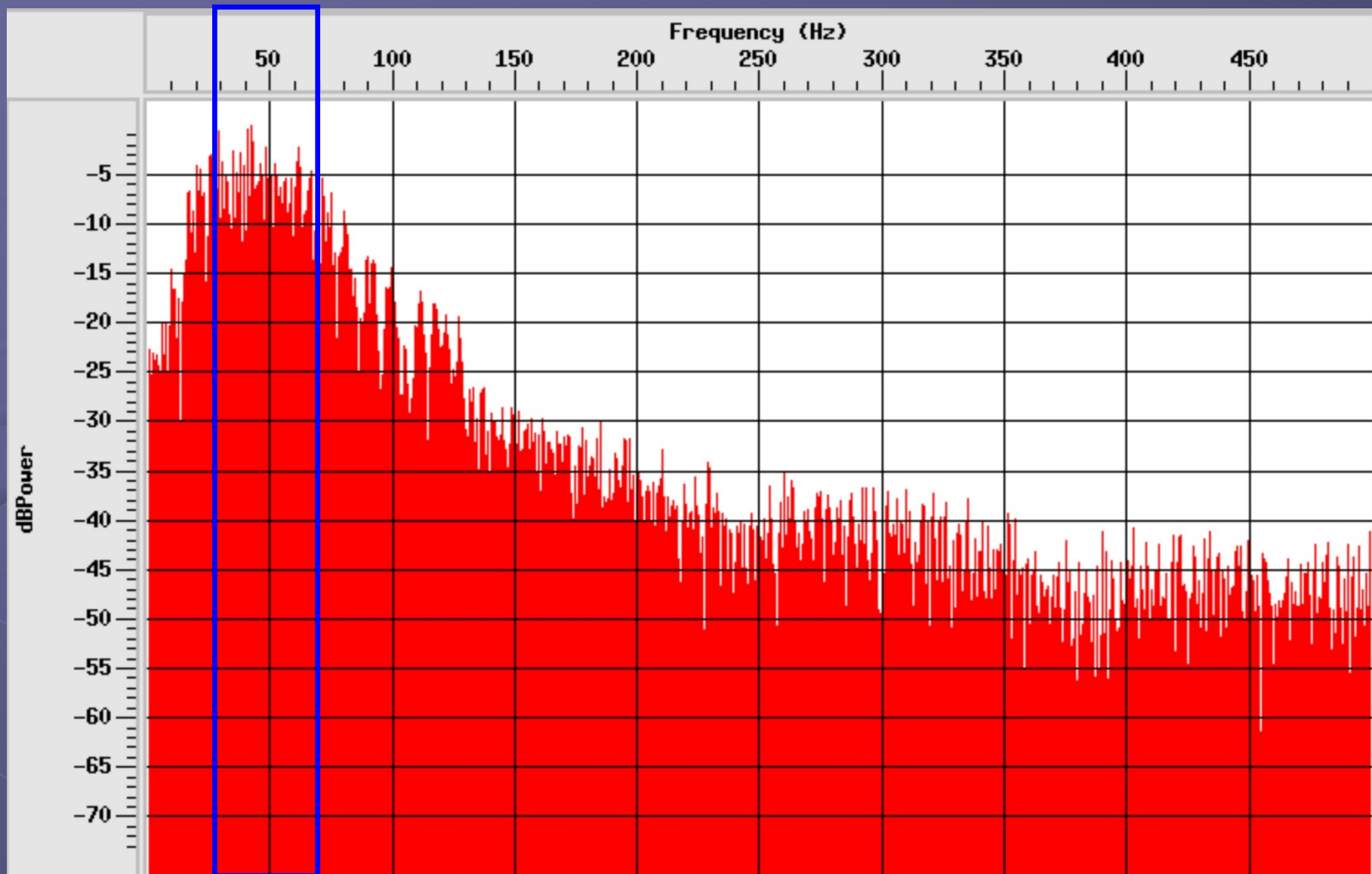
# Sequence Stratigraphy



# Outline

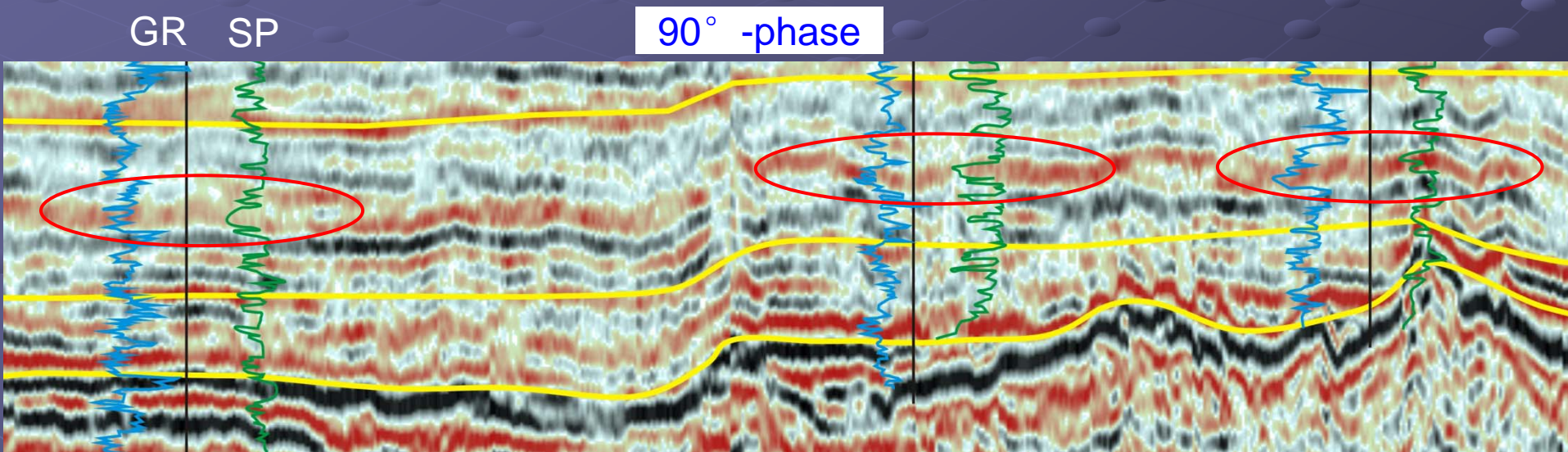
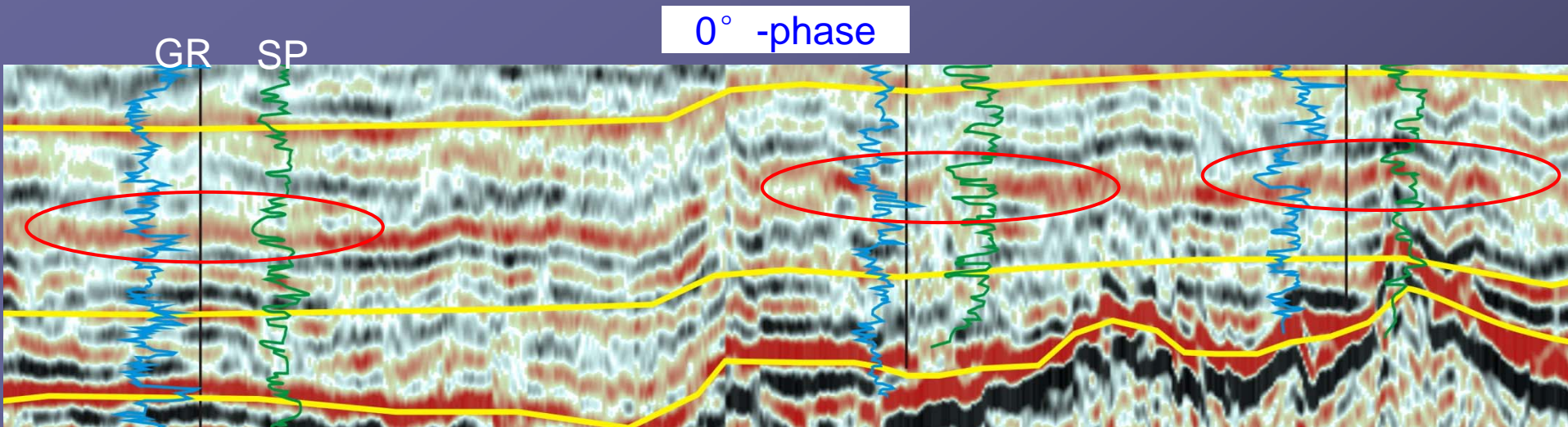
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# Dominant Frequency 30-60 Hz





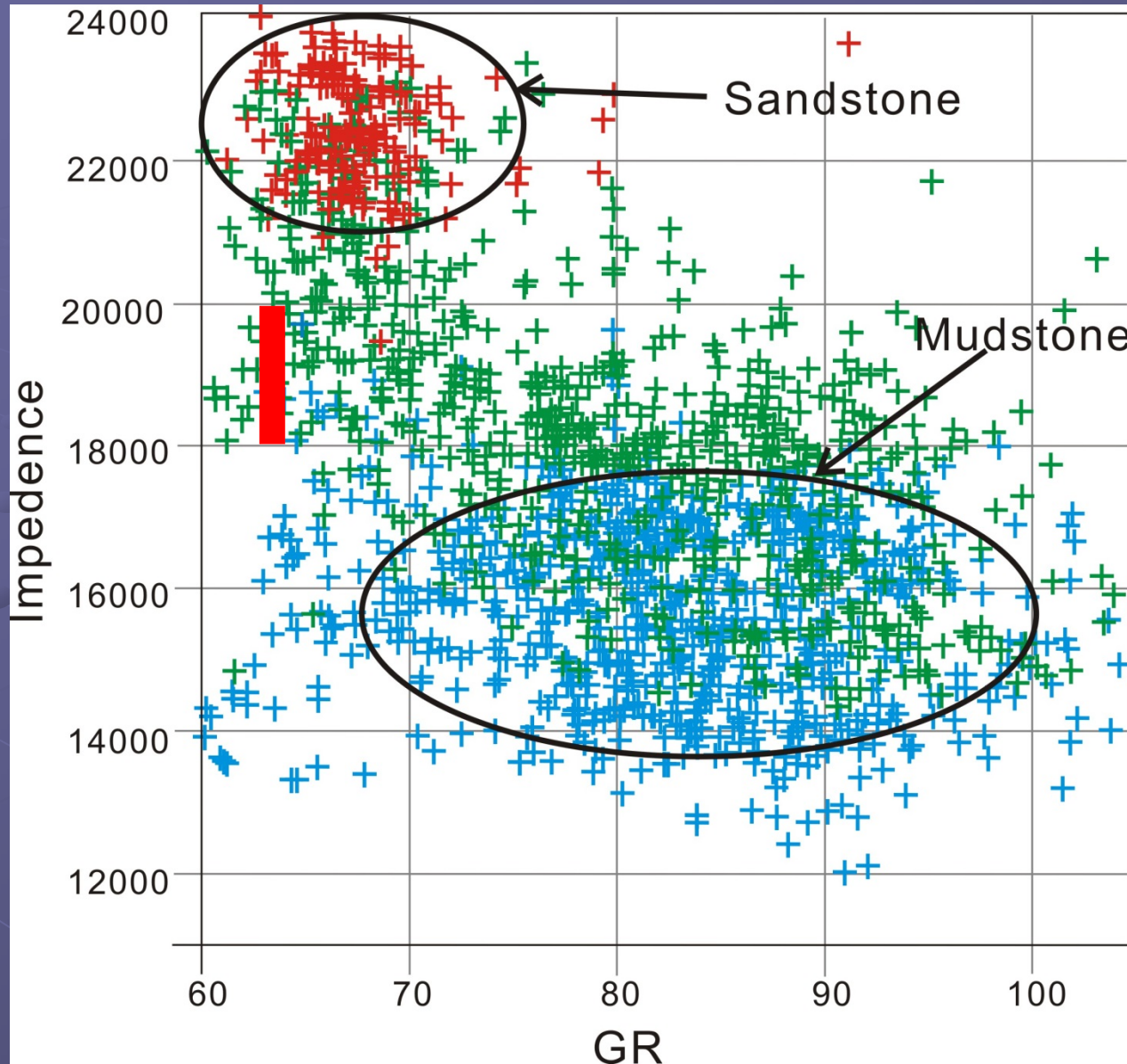
# 90° -Phase Shifting



Seismic amplitude section is converted into a lithologic section after 90° - phase shift especially for thin sandstone-bed deposition



# Rock-Physics Analysis



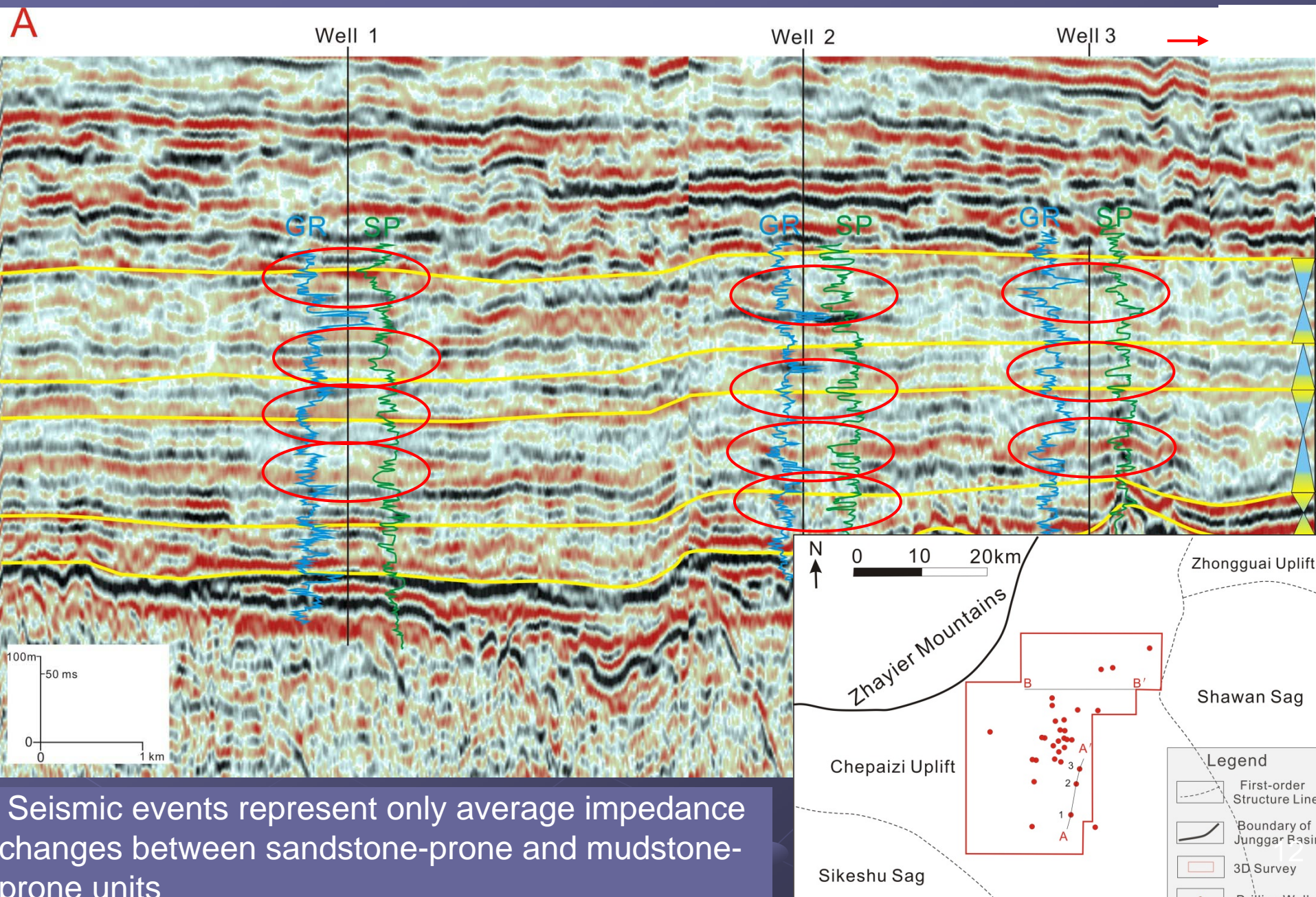
Rock-physics relationship is needed to predict the lithology in slices

**3 steps are needed:**

1. GR-impedance cross plot is employed to analyze the relationship between lithology and impedance;



## 2. Analysis of the degree of lithology-decomposition by seismic reflection;



# Rock-Physics Analysis

3. The relationship between impedance (polarity) and lithology is established.

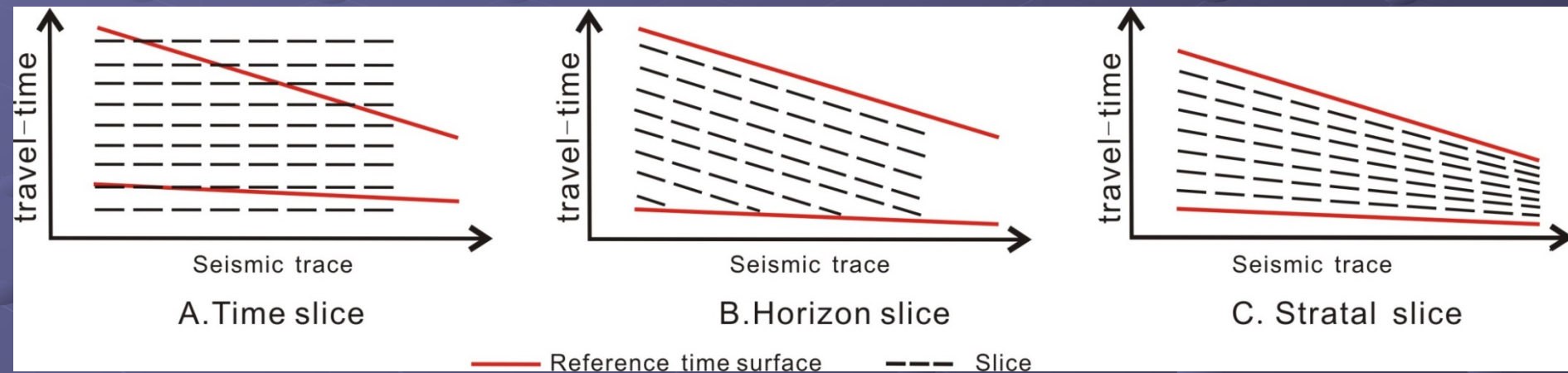
No.	System tract	Relative-impedance	Average-polarity	Interpretation of amplitude
1	transgressive	medium-high	trough	sandstone-prone facies
2	transgressive	low	peak	Strong amplitude indicates mudstone facies
3	regressive	high	trough	Strong amplitude indicates increase of sandstone
4	regressive	Medium-low	peak	mudstone-prone facies

In most cases, the strengthening of negative amplitude within seismic event was possibly related to the increase of sandstone content.



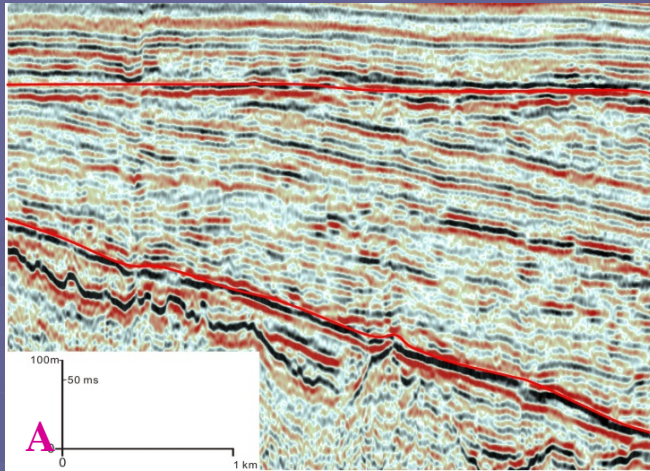
# Stratal Slicing

Stratal slice is the seismic-amplitude surface display which can be extracted from a depositional surface (geologic-time surface) to represent the full extent of a depositional system in the seismic survey.

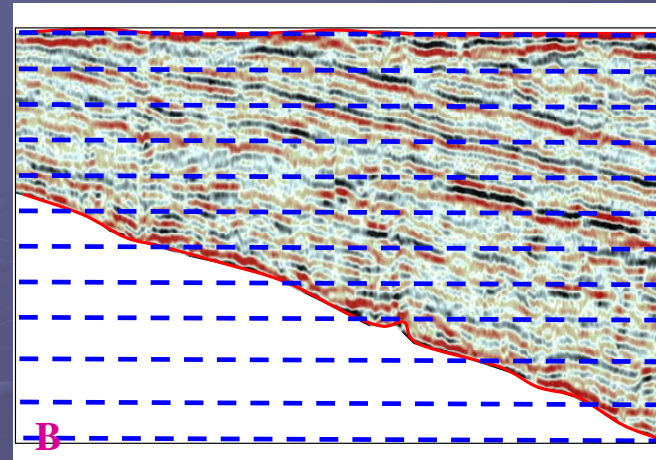


(Zeng, 1998)

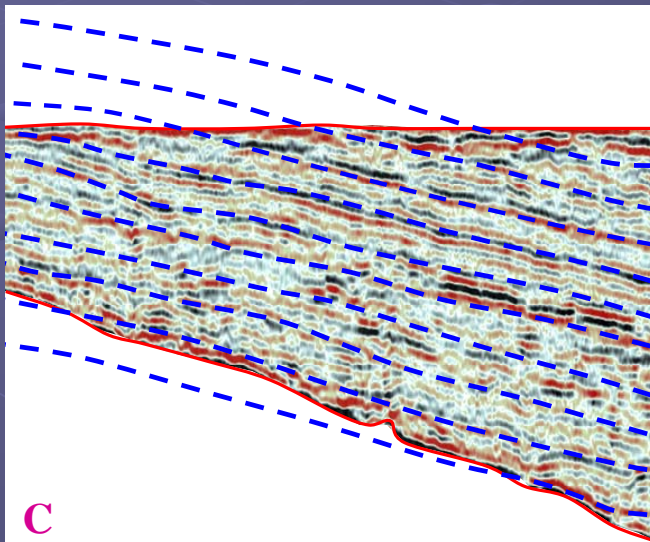
# Stratal Slicing



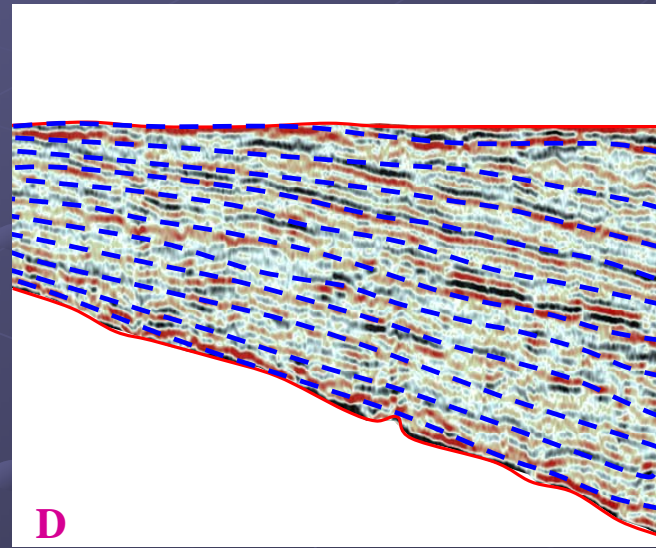
Original seismic section



Time slice



Horizon slice

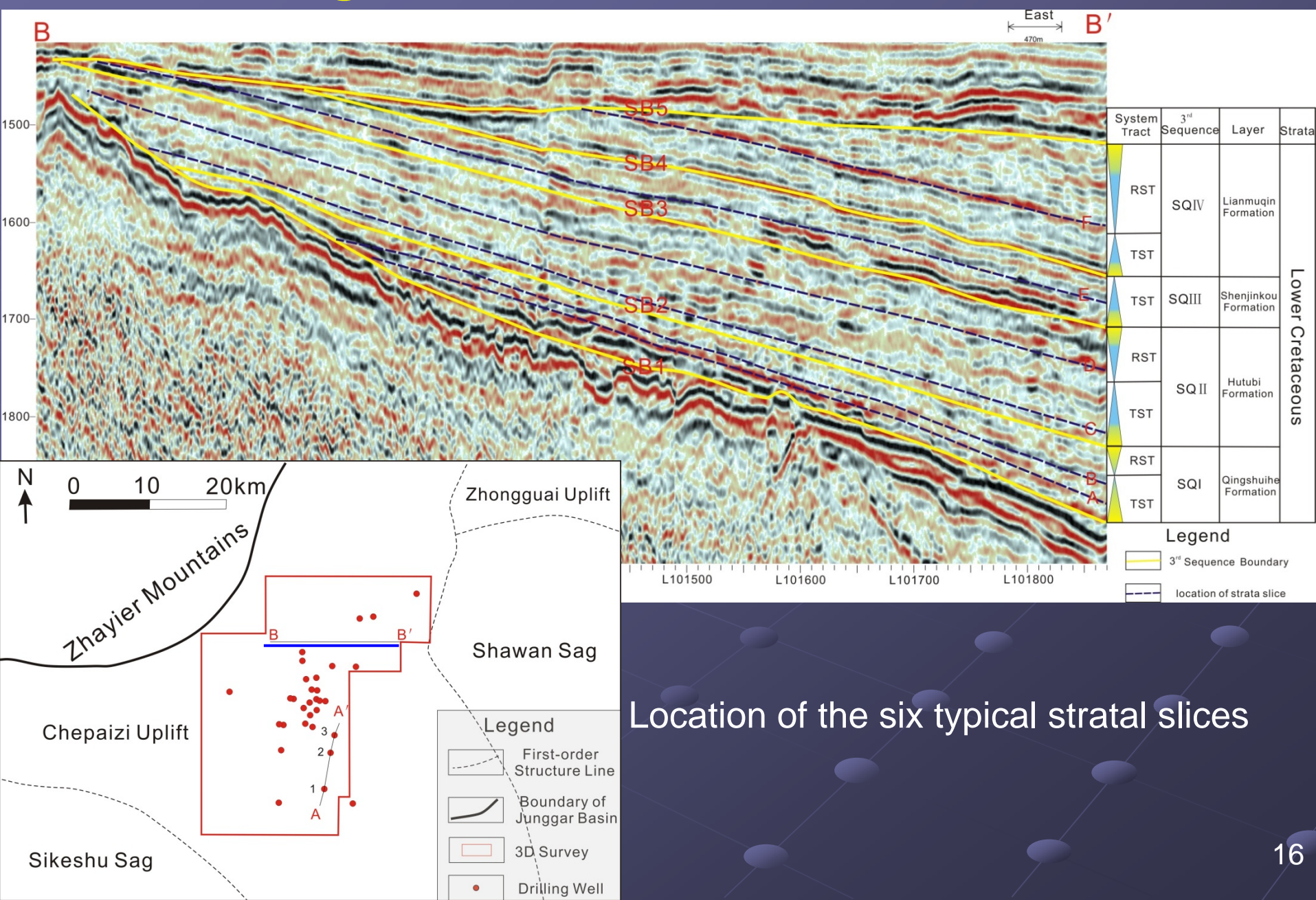


Stratal slice

The Lower Cretaceous intervals of the study area appear as a typical wedge shape, characterized by significant lateral thickness variation and few growth faults.

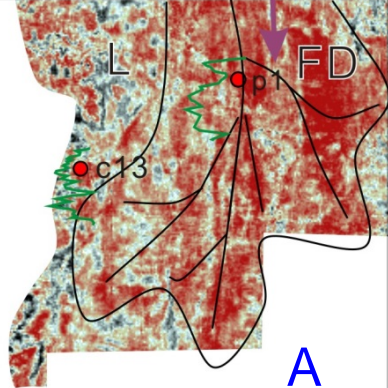
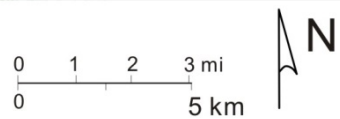


# Stratal Slicing

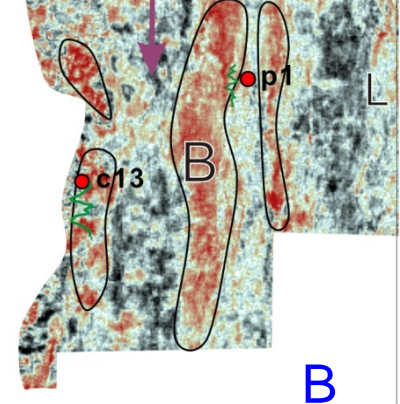
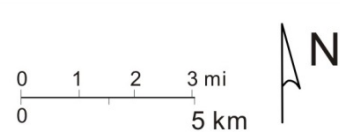


Location of the six typical stratal slices

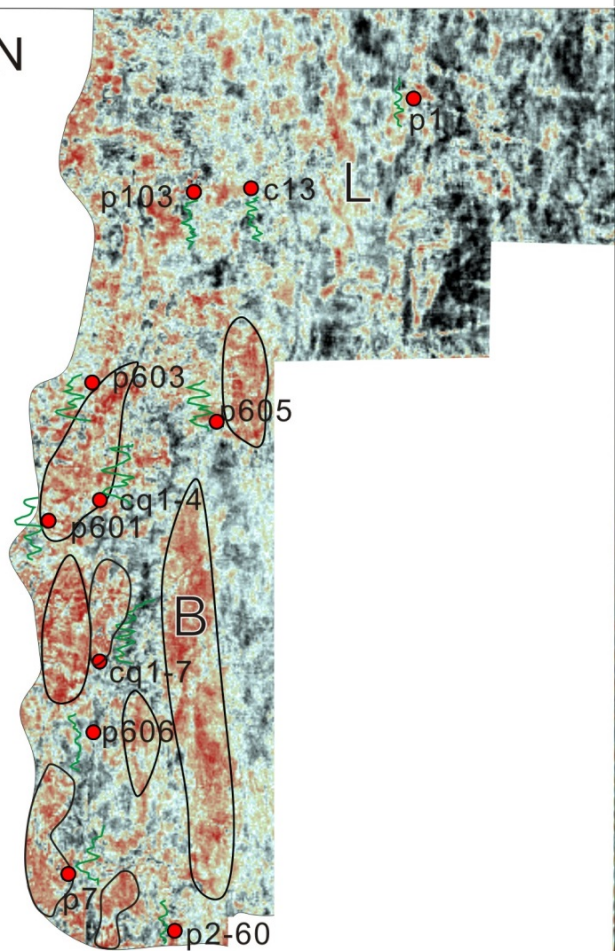
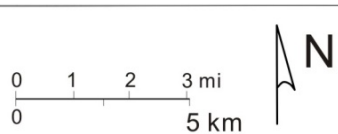




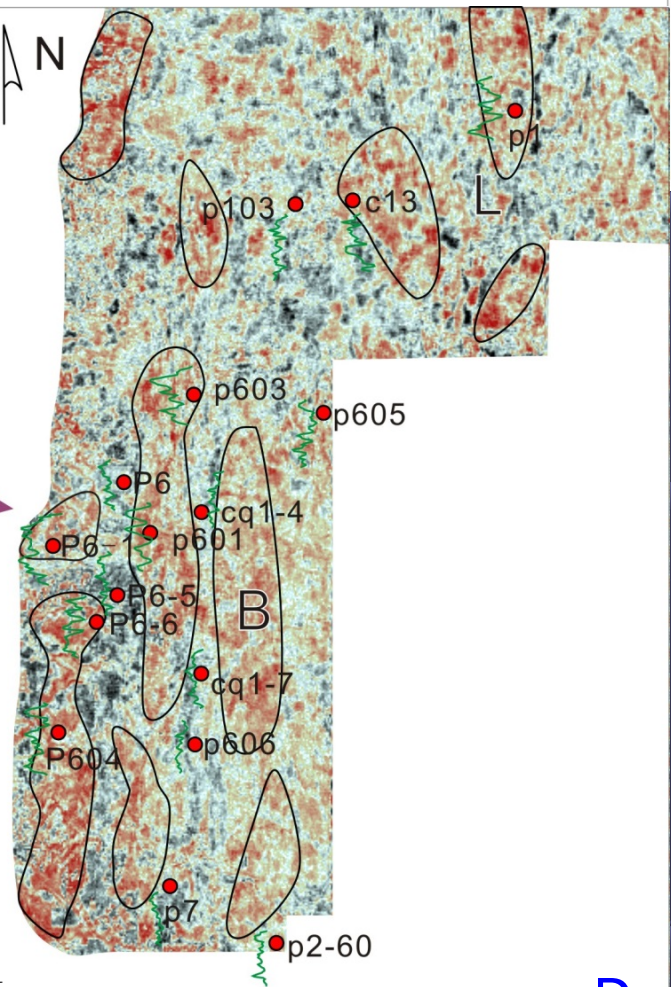
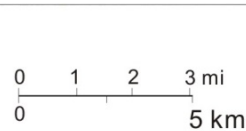
Early TST of SQ I



Late TST of SQ I

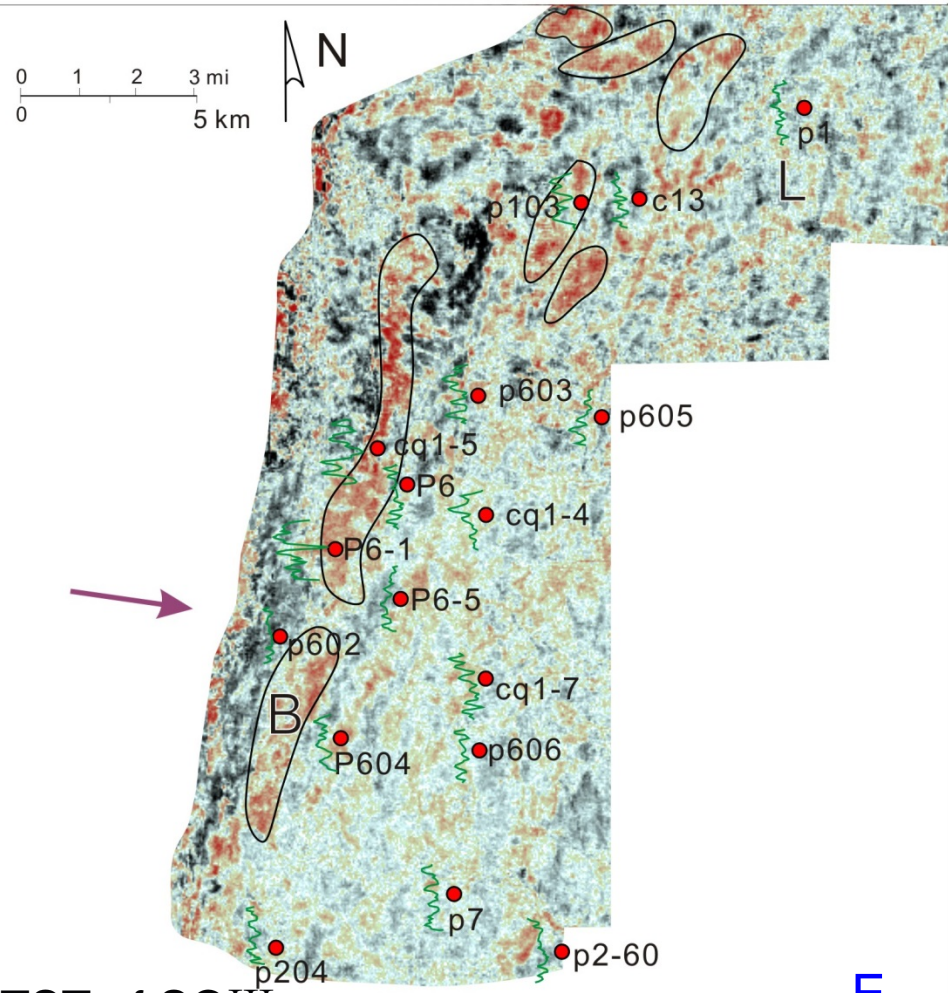


TST of SQ II



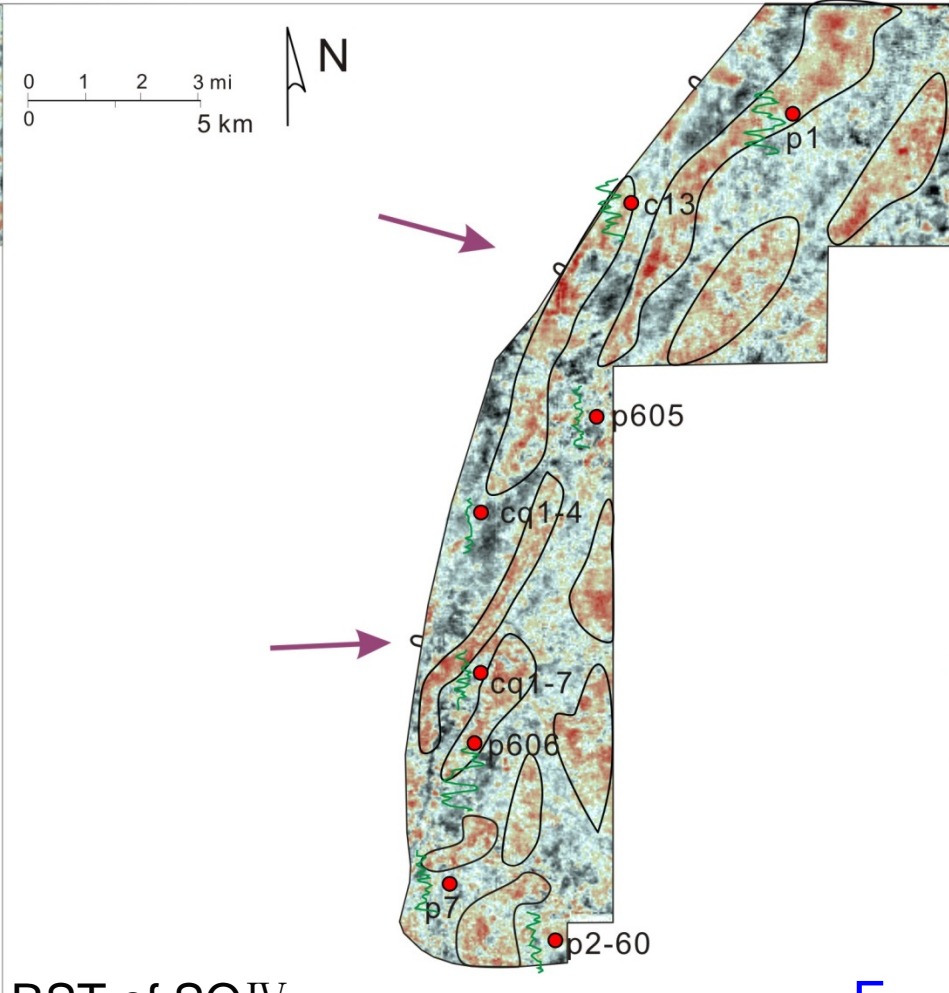
RST of SQ II

# Stratal Slicing



TST of SQIII

E



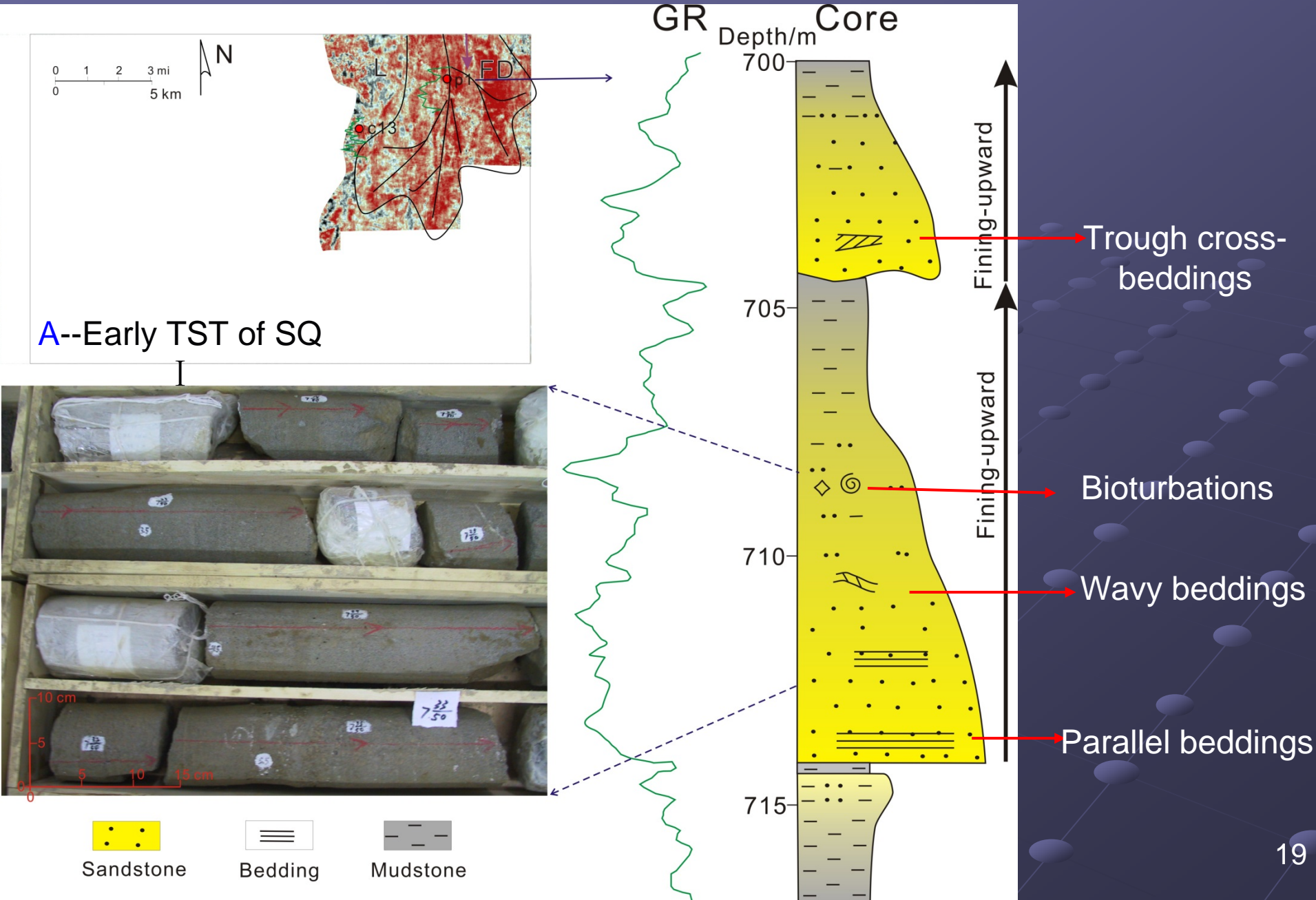
RST of SQIV

F

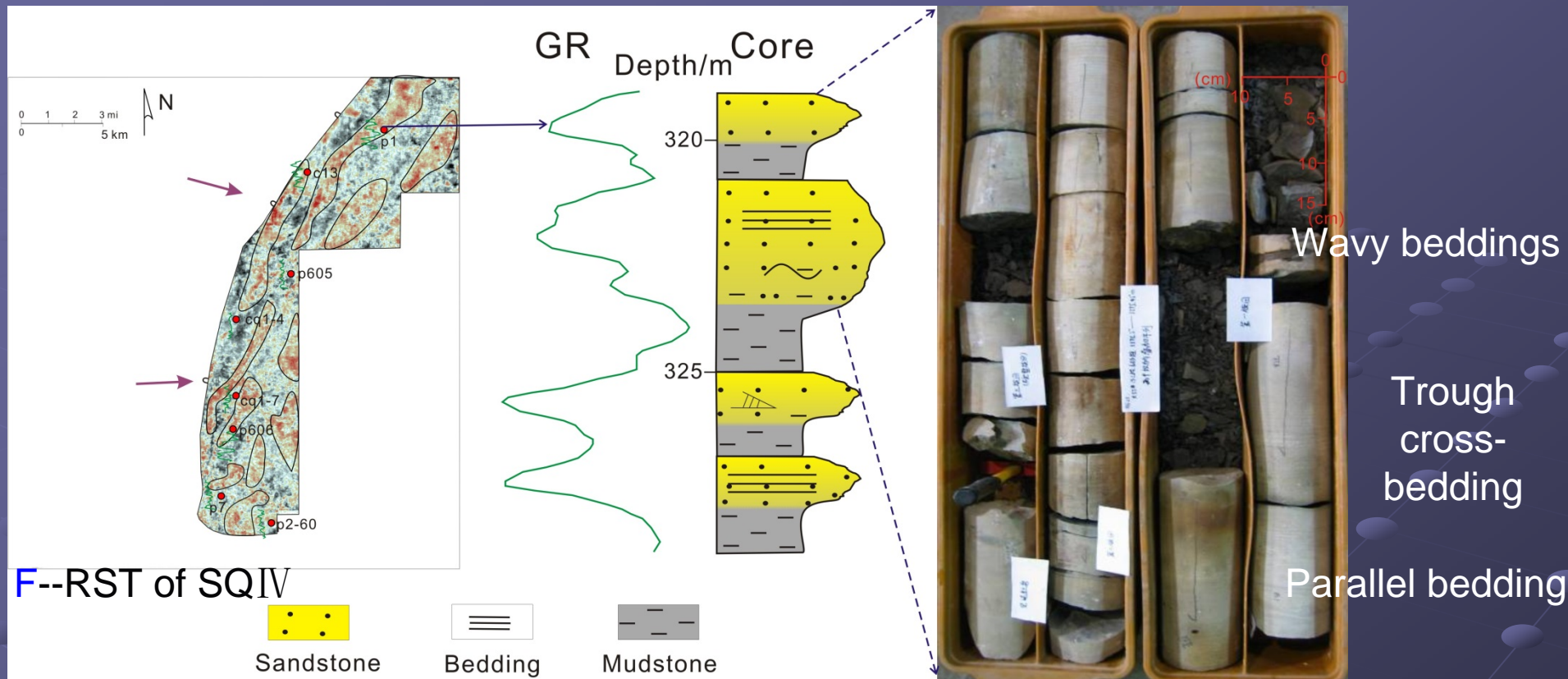
FD= Fan delta    L= Lake    B= Beach and bar     Source direction     4m GR log     - Amplitude +



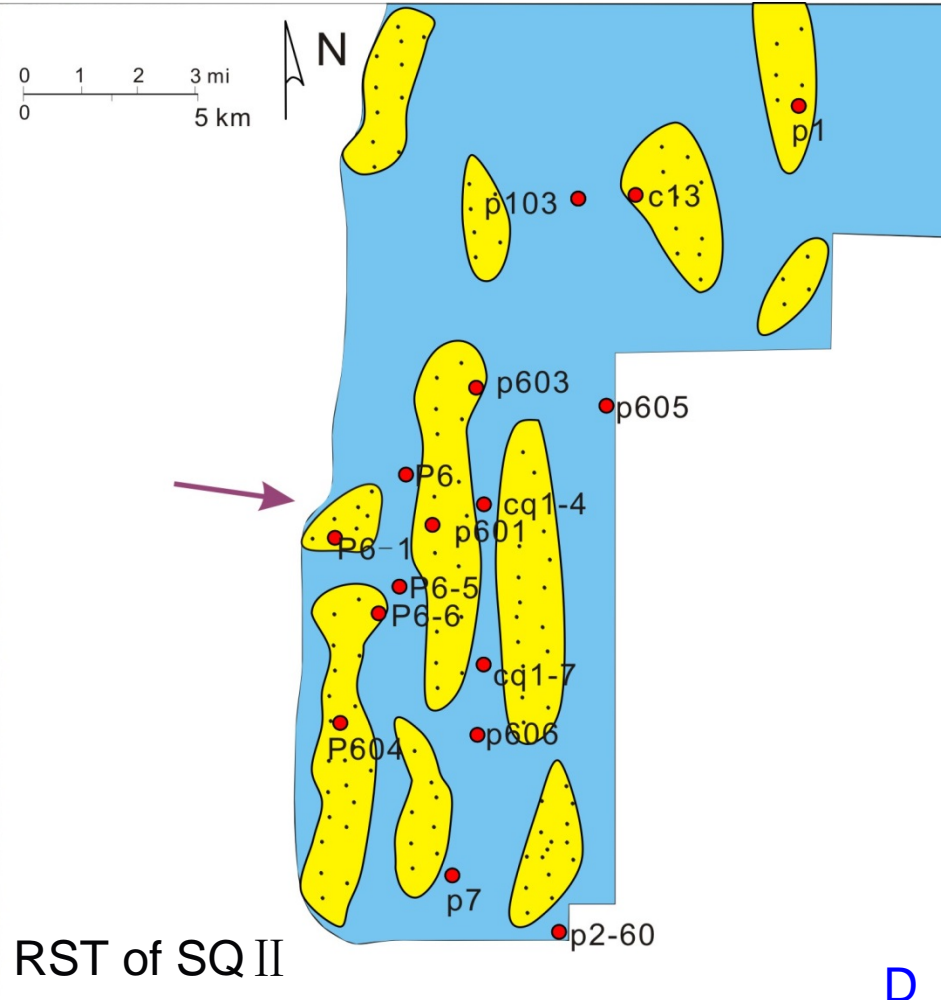
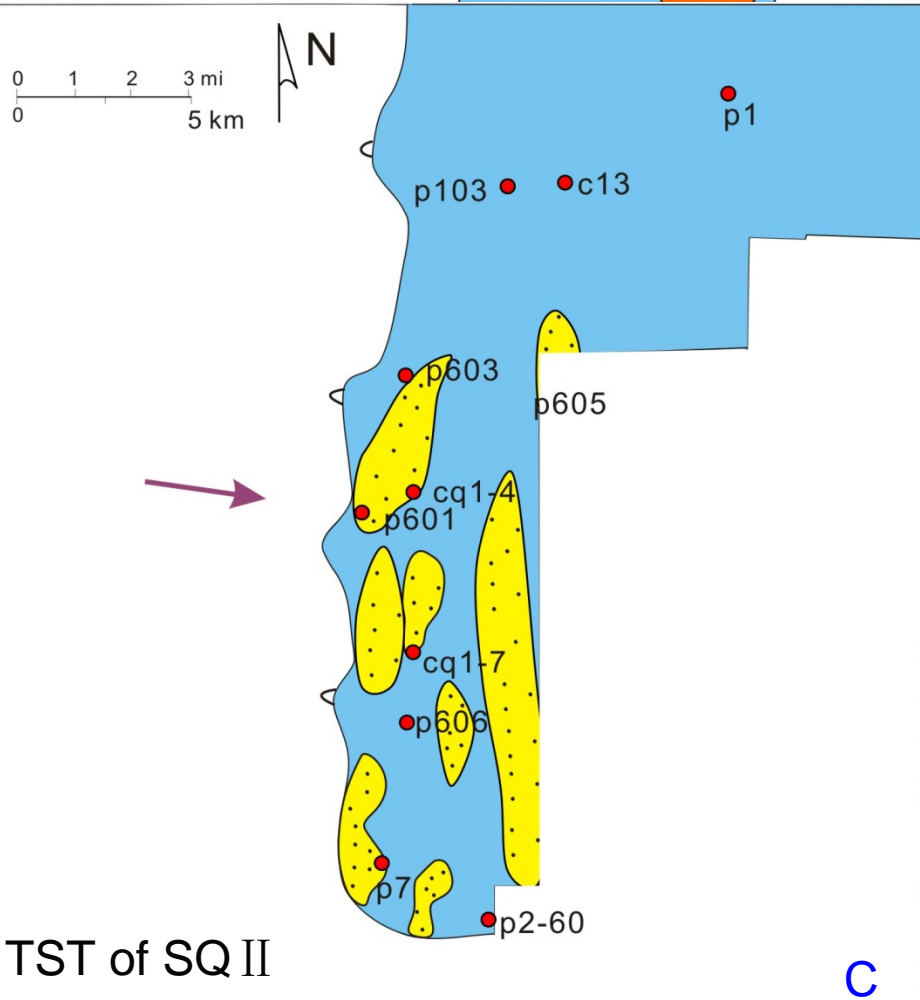
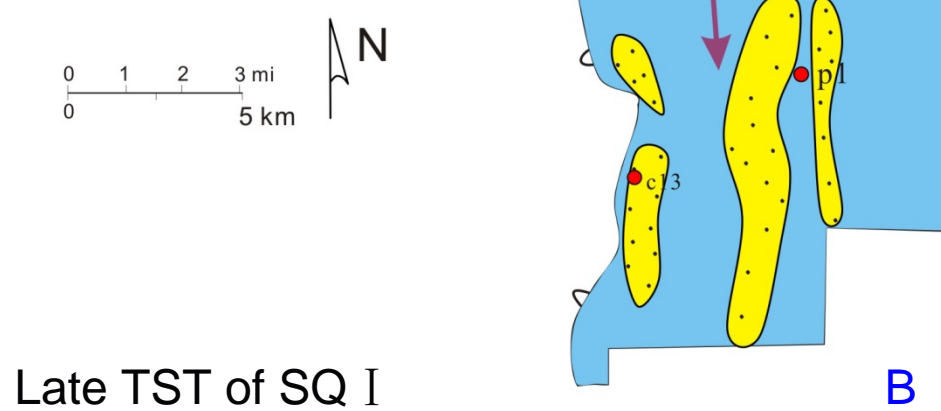
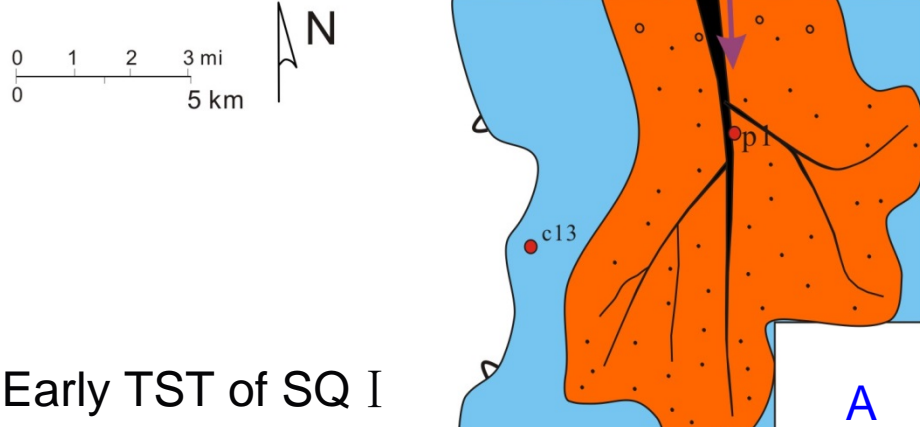
# Core-Well-Seismic Calibration



# Core-Well-Seismic Calibration

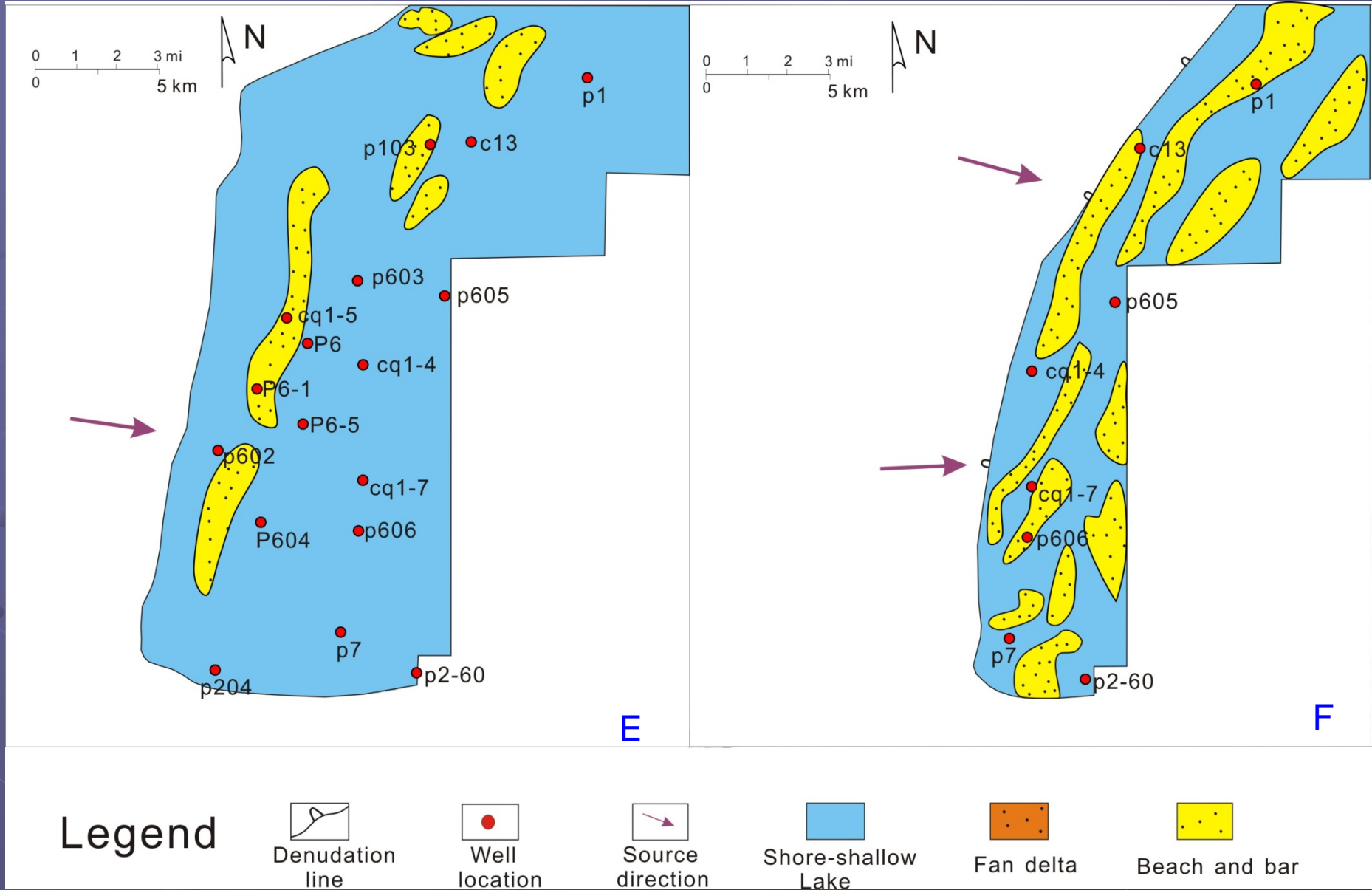


Several siltstone to fine-grained sandstone depositional sequences interbedded with thin layers of mudstone, which is interpreted as beach and bar deposits in regressive system tract, are corresponding to medium-strongly negative amplitude on stratal slice F.





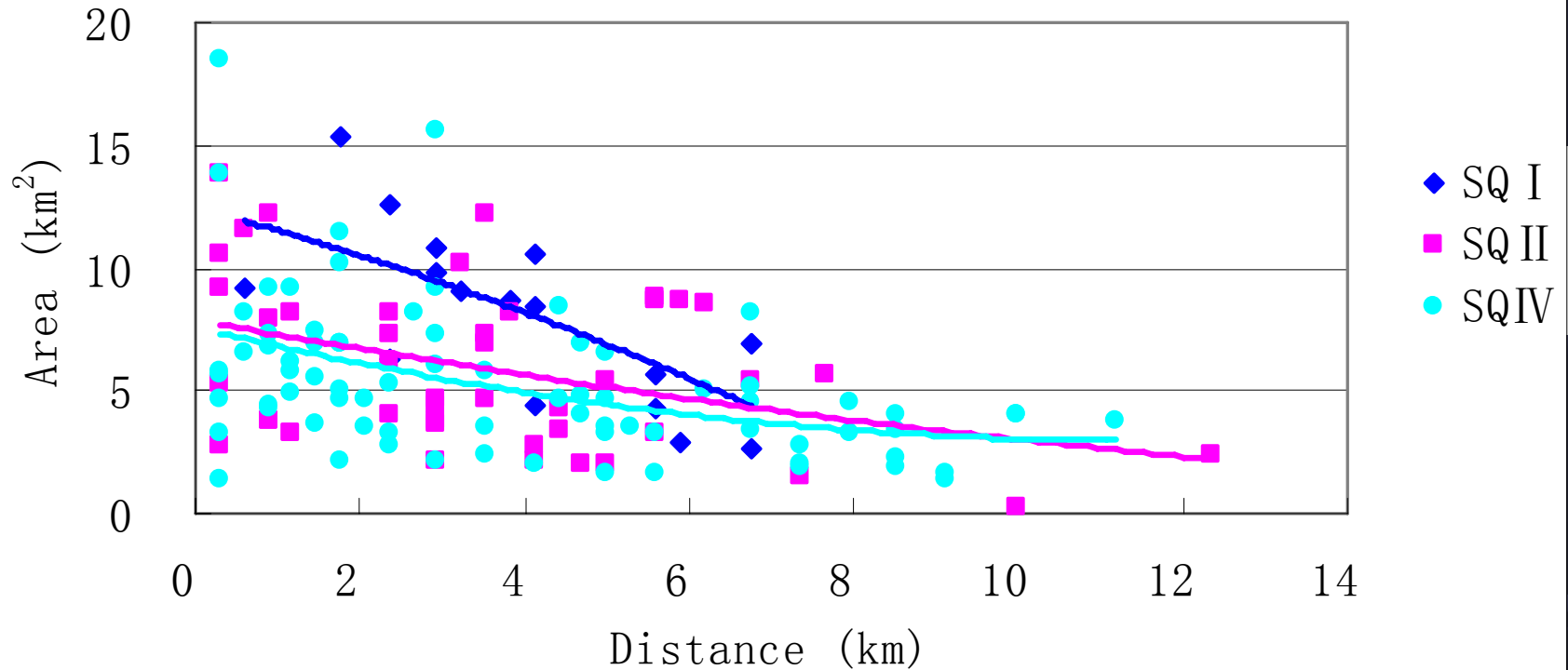
# Geology Interpretation



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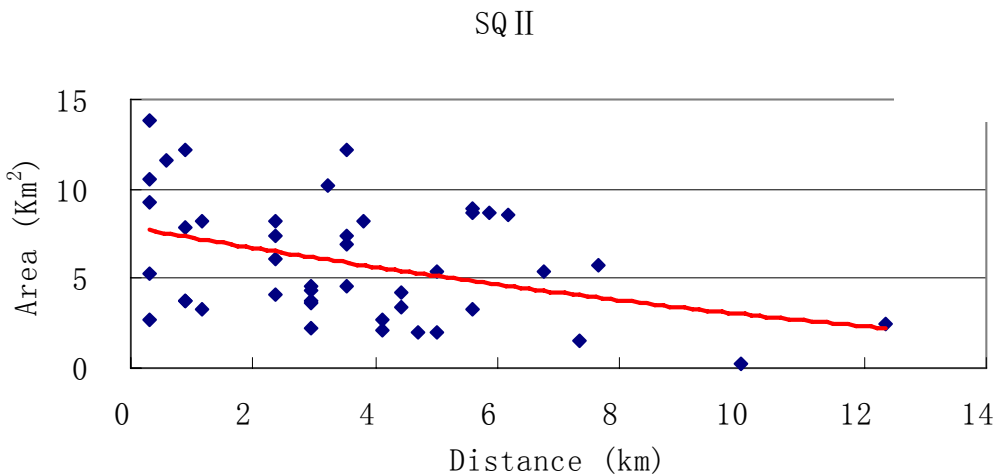
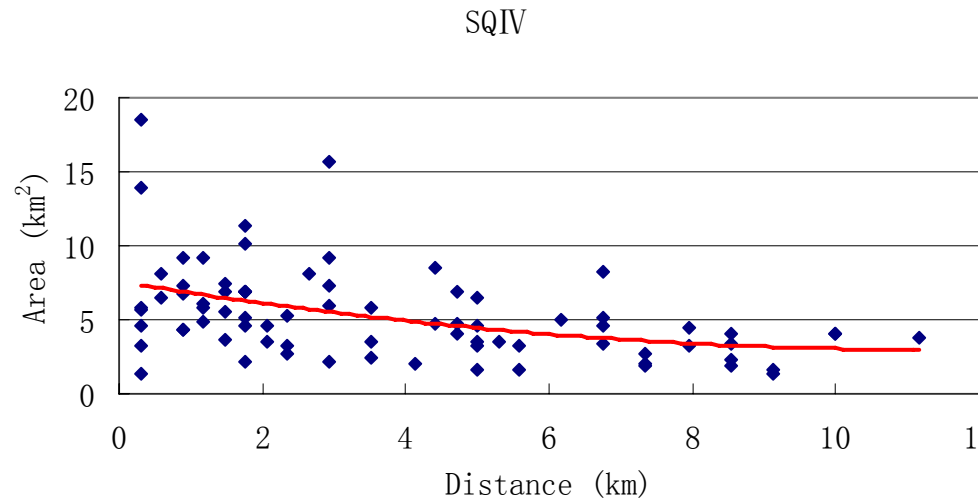
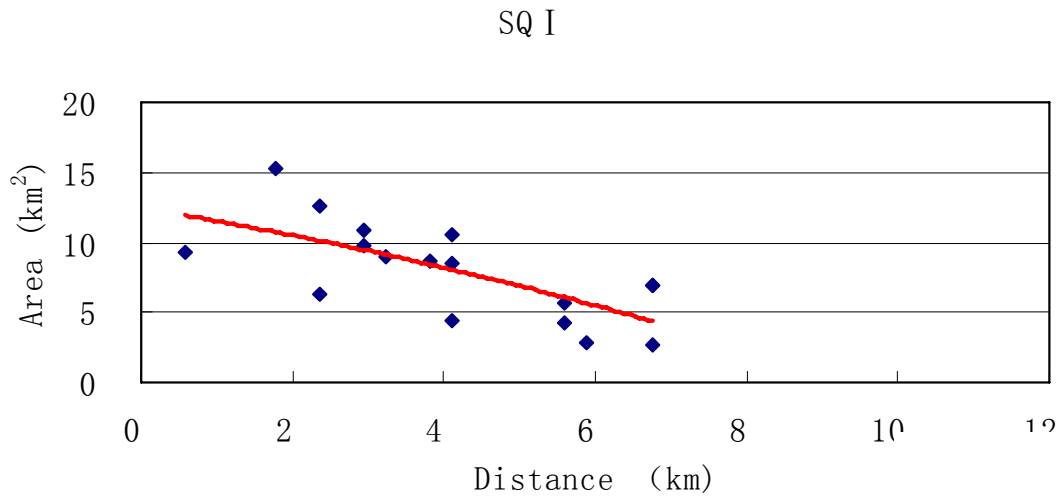
# Quantitative Analysis



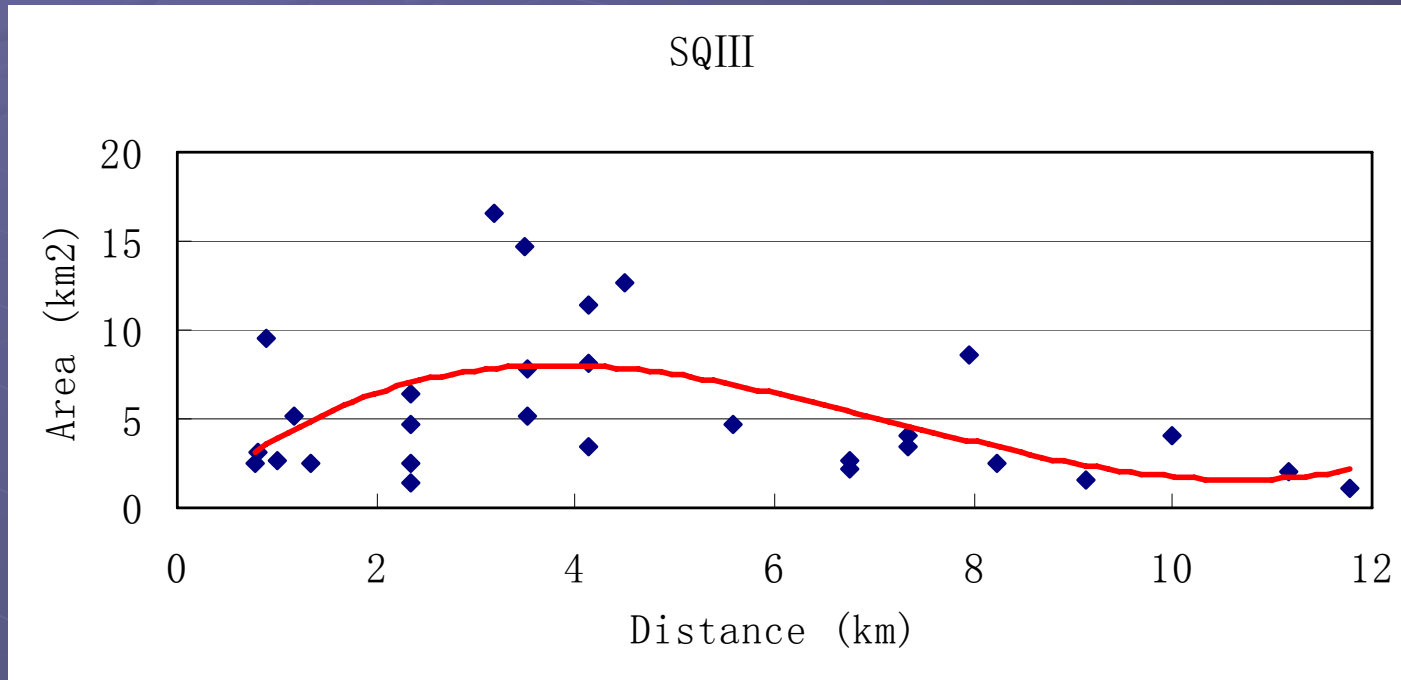
Area---beach and bar distributing area;

Distance---the distance from beach and bar to the western uplift.

# Quantitative Analysis

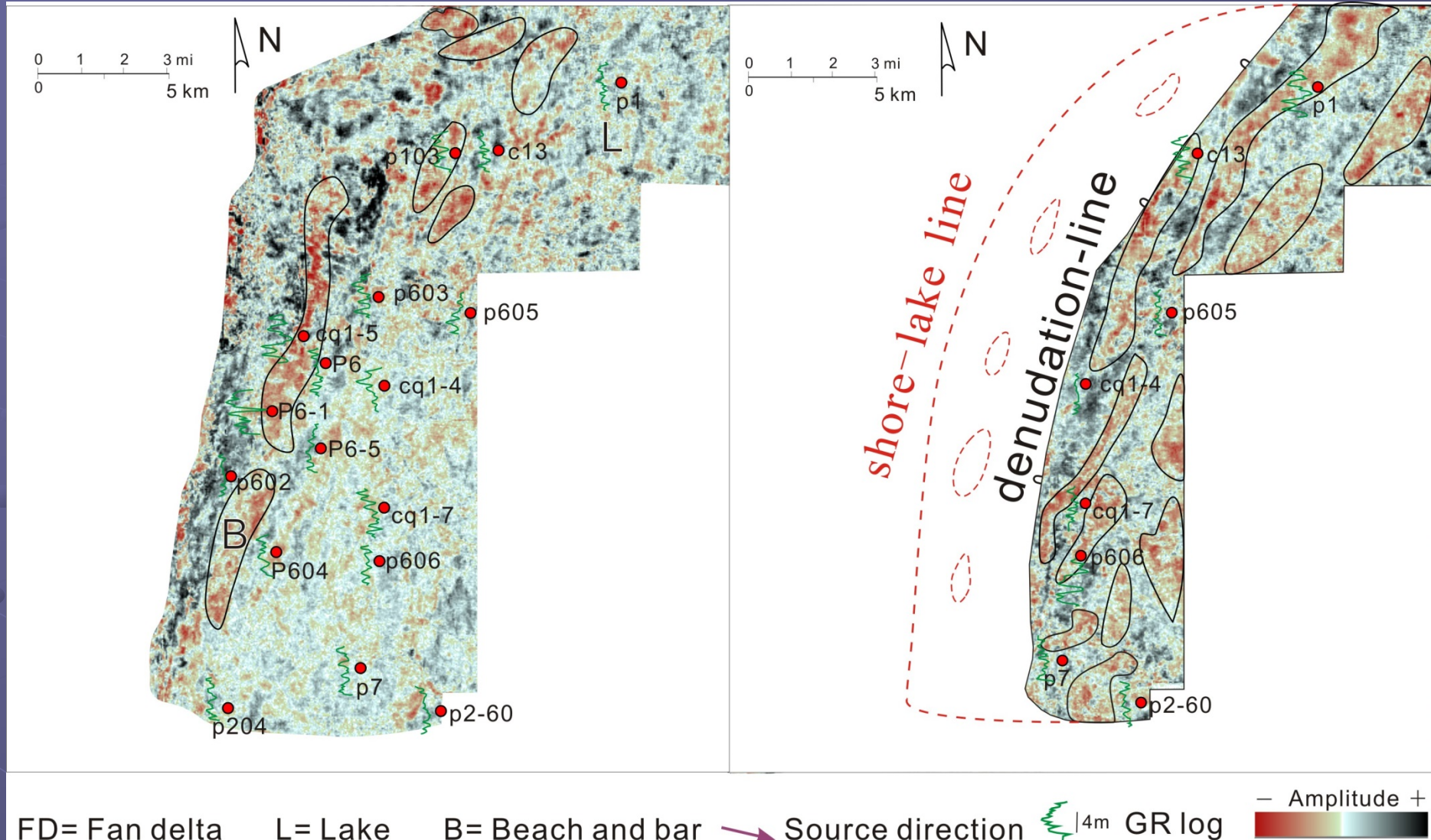


# Quantitative Analysis

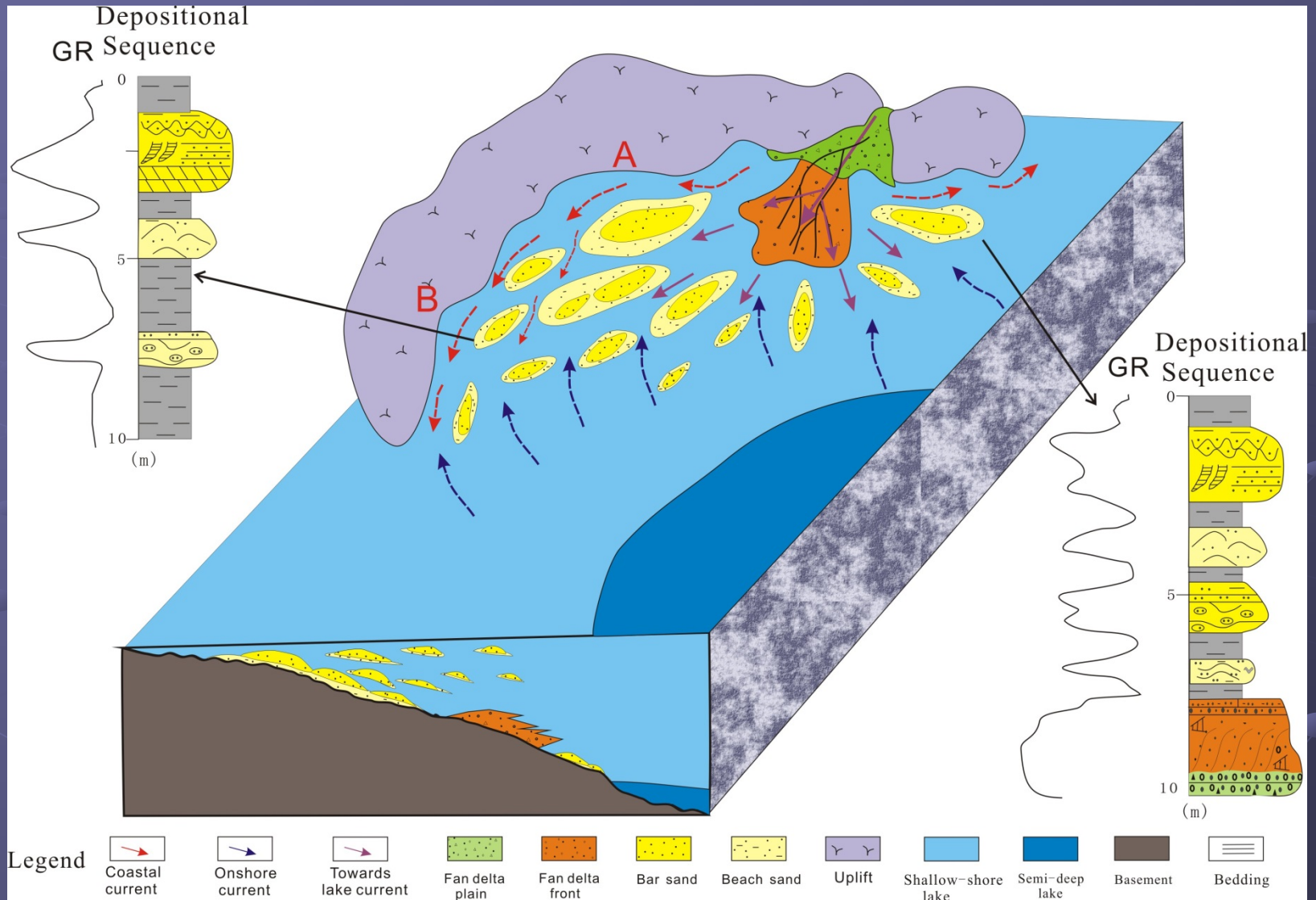




# Geology Interpretation



# Depositional Model



The formation of beach and bars of the study area controlled by provenance, hydrodynamic condition and system tract cycle.

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# Conclusions

- ✓ Four third-order sequences are identified, interpreted, and correlated throughout the study area on wire-line logs seismic sections.
- ✓ For seismically thin beds,  $90^\circ$  -phasing is probably the simplest and most reliable way to convert a seismic volume into a lithology volume.
- ✓ After  $90^\circ$  -phase shift, the analysis of rock-physics relationship is also necessary for establishing the corresponding relationship between seismic amplitude and lithology in order to carry on seismic geomorphology investigation.
- ✓ Seismic sedimentology mainly relies on amplitude-dispersal-pattern analysis to define the spatial and temporal relationships of sedimentary rocks and depositional systems preserved in the basin.
- ✓ The development of beach and bar sandbodies is controlled by the interaction of relative lake level change, sediment supply, and system tract cycle, hydrodynamic energy.



# Acknowledgement

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