Tectono-sequence Stratigraphy of Lower Cretaceous in Ta'nan Depression, Tamtsag Basin, Mongolia: Sequence Architecture, Depositional Systems and Controls on Sediment Infill*

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Abstract

Tectonics is very important to the depositional record preserved in nonmarine sedimentary basins. The episodic syndepositional faulting and the related paleogeomorphology control both the formation of sequence boundaries and the stratal stacking patterns. In this study, the sequence architectures, depositional systems and controls on sediment infill of the Lower Cretaceous in Ta'nan Depression, Tamtsag Basin in Mongolia were investigated using seismic profiles, cores and well logs.

Based on the identification of unconformities of different hierarchies, three second-order sequences and four third-order sequences are identified in the Lower Cretaceous lacustrine rift-basin successions. According to the subsidence rate and the intensity of tectonic activity, three types of lacustrine sequences, consisting of distinctive depositional systems, were distinguished: (1) simple half-graben sequences developed during the initial rifting stage; (2) tectonic-rollover sequences developed in response to rapid and differential tectonic subsidence during the climax -rifting stage; and (3) depression sequences formed during the late-rifting stage.

The sequence development is mainly controlled by tectonics and sediment supply. Due to the differential tectonic subsidence rate and sediment supply, the accommodation/sediment supply ratio (A/S) varies greatly in both different tectonic positions and stages of rifting, resulting in a wide variety of stratal stacking patterns.

Through episodic rifting and differential subsidence, various types of transfer zones and structural slope-break zones were formed, both of which play significant roles in formation and distribution of different types of sequences and depositional systems within. Transfer zones controlled the locations of sedimentary provenances, entry points of sedimentary material into the basin, and the resultant development of depositional systems. The structural slope-break zones of Ta'nan Depression during the climax rifting stage of K1n would be subdivided into four types from the steep slope to the gentle slope, they are: fault scarp zones, fault terrace zones, intrabasinal fault break zones and gentle slope zones.

Furthermore, three fault array patterns were identified according to their distribution on the structure map, which are "comb-like", "fork-like and "parallel". The structural slope-break zones mainly influence the distribution of depositional systems and sand bodies, the sand bodies are mainly accumulated at the lower part of tectonic slope-break zones, and the rift-interior sediment dispersal directions are consistent with the strike of the slope-break zone.

Areas where the structural slope-break zone overlapped with transfer zones are sites for major drainage systems and the optimum locations of fan deltas and sublacustrine fans. The sand bodies deposited here are favorable targets for the exploration of litho-stratigraphic traps in Ta'nan Depression.

Selected References

Van Wagoner, J.C., H.W. Posamentier, R.M. Mitchum, P.R. Vail, J.F. sarg, T.S. Loutit, and J. Hardenbol, 1988, An overview of the fundamentals of sequence stratigraphy and key definitions, *in* Sea Level Changes – An Integrated Approach: SEPM Special Publication No. 42, p. 39-45

Morley, C.K., R.A. Nelson, T.L. Patton, and S.G. Munn, 1990, Transfer zones in the East African Rift system and their relevance to hydrocarbon exploration in rifts: AAPG Bulletin, v. 74/8, p. 1234-1253.

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Tectono-sequence Stratigraphy of Lower Cretaceous in Ta'nan Depression, Tamtsag Basin, Mongolia:

Sequence architecture, depositional systems and controls on sediment infill

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Outline

1. Introduction

2. Geological setting

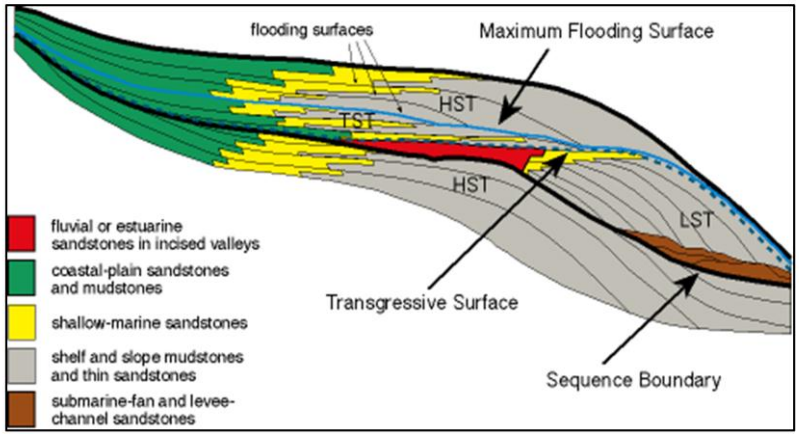
3. Sequence models of syn-rift lacustrine basins

4. Tectonic controls on distribution of basin fills

5. Conclusions

1. Introduction

Sequence models



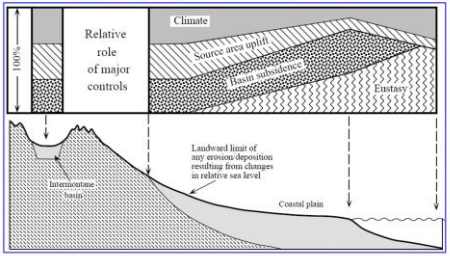
(Van Wagoner, et. al., 1988)

Presenter's notes: In recent years, the fundamental principles of sequence stratigraphy have been applied to analyze the basin fills in various tectonic settings to predict the distribution of depositional systems and sand bodies.

1. Introduction

Controlling factors on sequence development

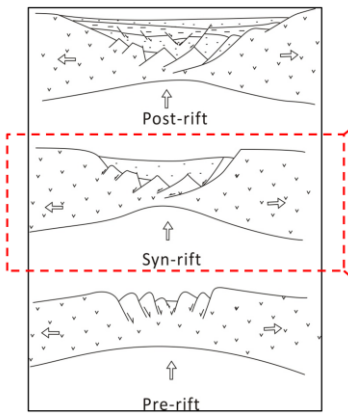
Tectonic active basins



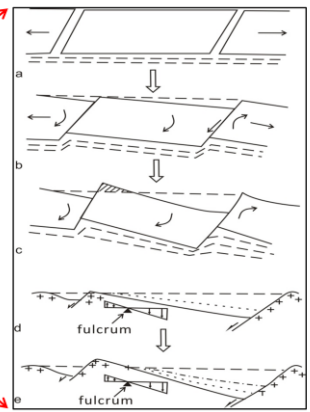
(Shenley, et al., 1994)

- Tectonic subsidence
- Sediment supply
- Climate

1. Introduction



Episodic rifting

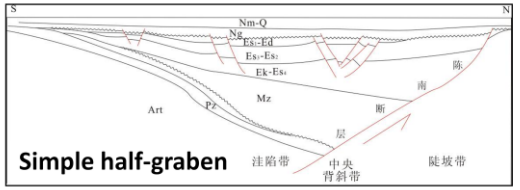


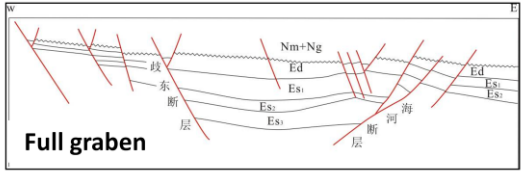
Rotation movement

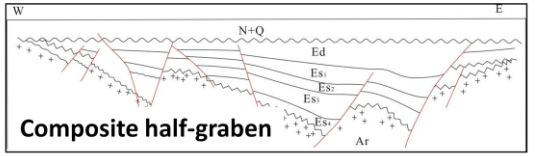
Various tectonic subsidence rate

1. Introduction

Basin architectures



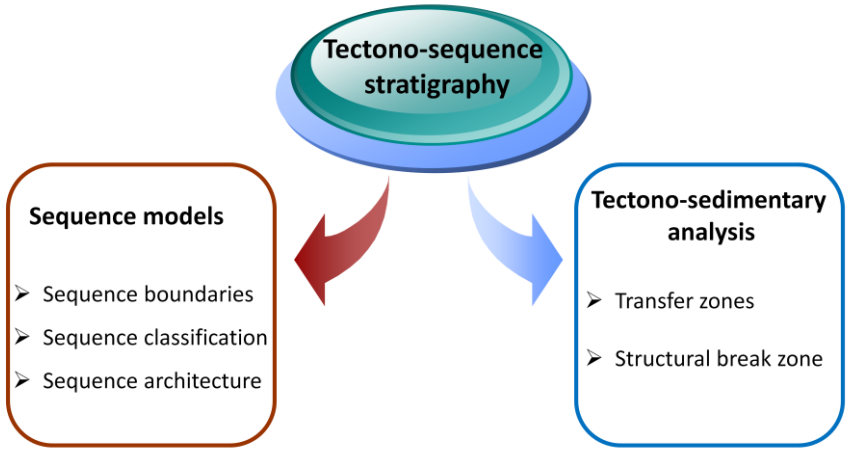




- Accommodation?
- Sequence architecture?
- Depositional systems?

1. Introduction

What I expect to go?



Predict the distribution of sand bodies in rift lacustrine basins

Outline

1. Introduction

2. Geological setting

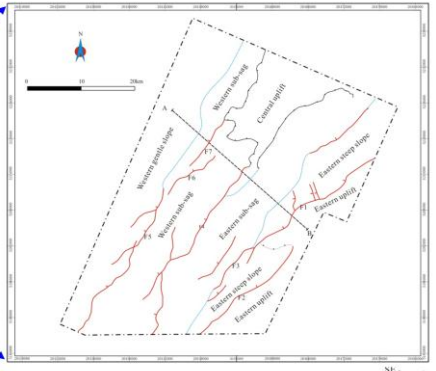
3. Sequence models of syn-rift lacustrine basins

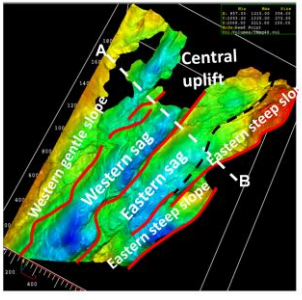
4. Tectonic controls on distribution of basin fills

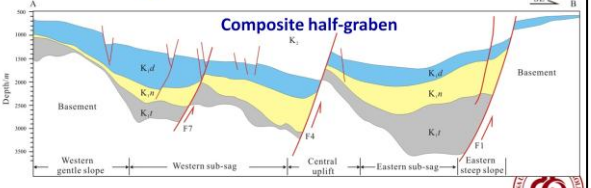
5. Conclusions

2. Geological setting

2.1 Location

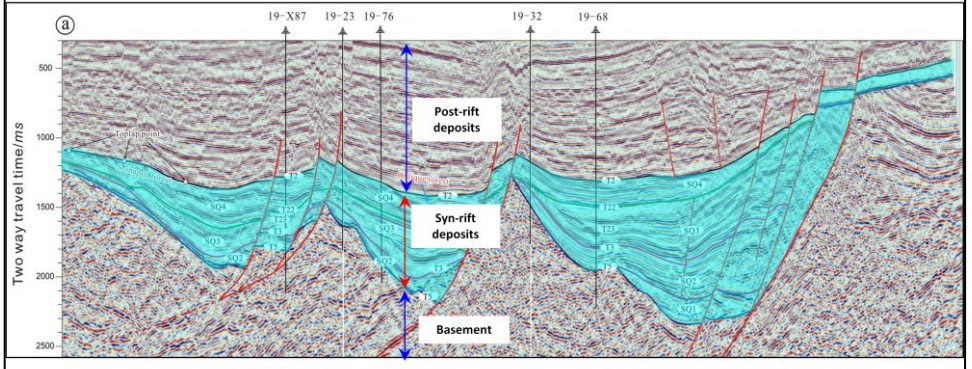






2. Geological setting

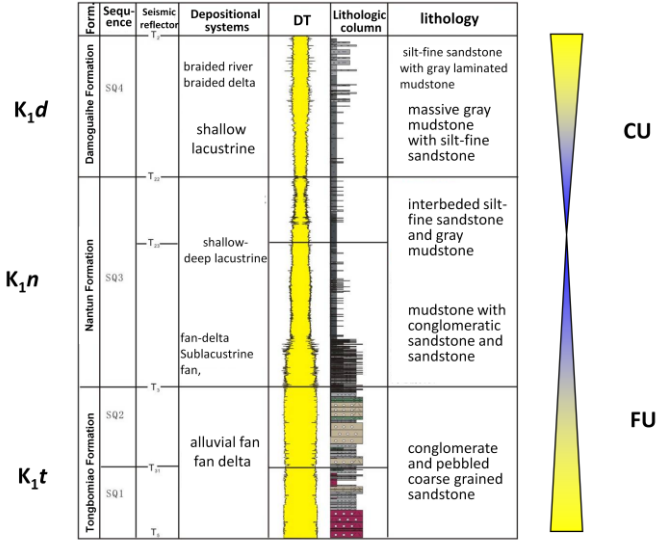
2.2 Strata



- Syn-fift stage (K_1)
- Post-rift stage (K_2)

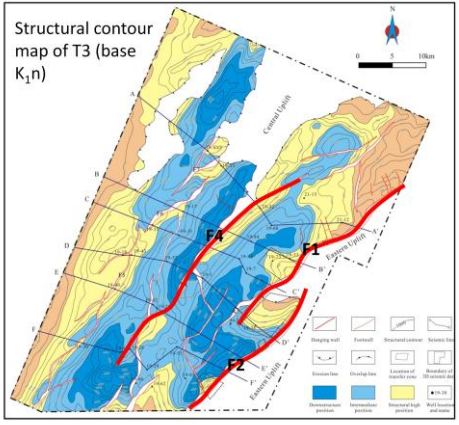
2. Geological setting

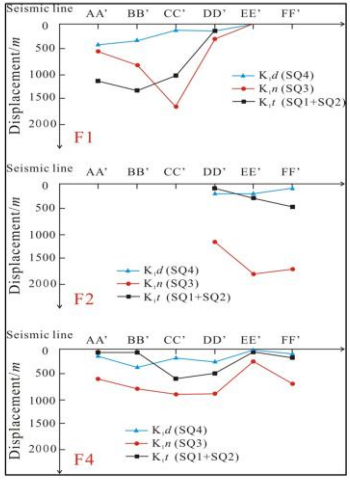
2.2 Strata



2. Geological setting

2.3 Tectonic evolution



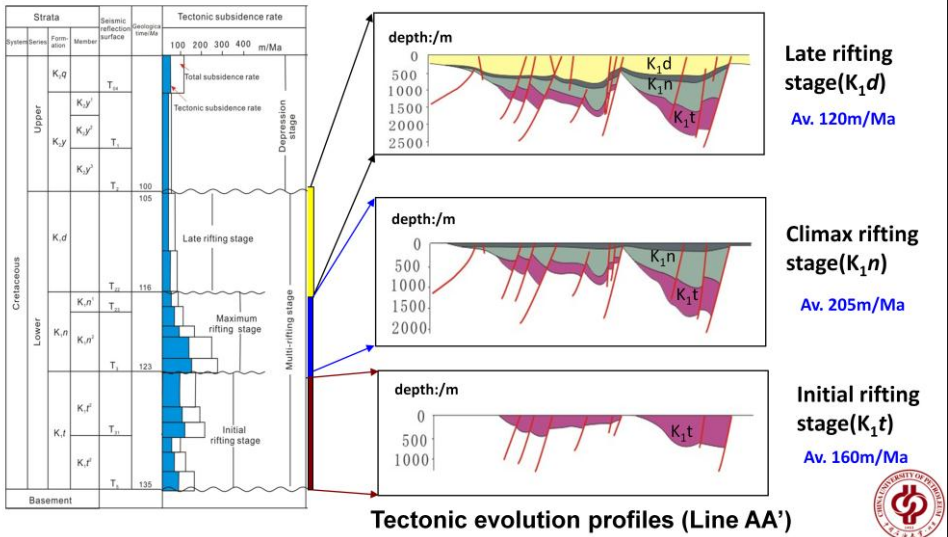


F1 and F2: Basin border faults

F4: Central fault

Episodic faulting activities

Episodic faulting activities in syn-rift stage



Presenter's notes: The sequence architectures and depositional systems are different during individual episodes of fault movement, due to differential tectonic subsidence rate and arrangement pattern of syndepositional faults in different tectonic position.

Outline

1. Introduction

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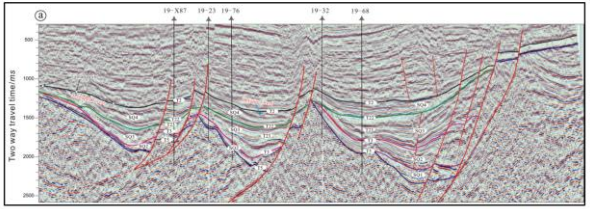
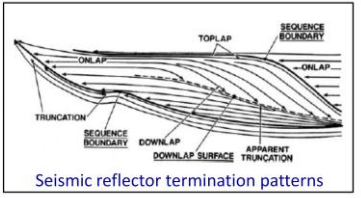
4. Tectonic controls on distribution of basin fills

5. Conclusions

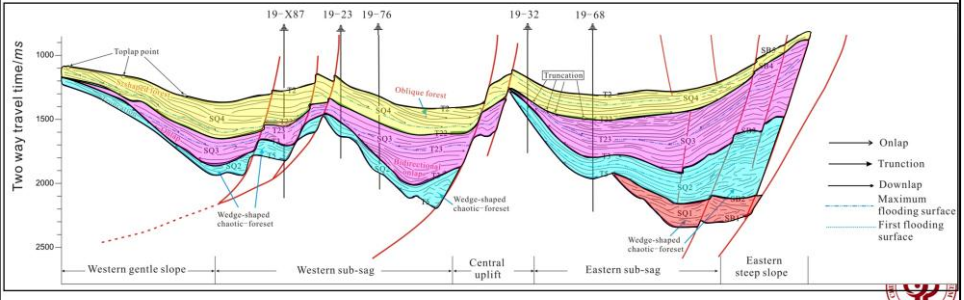
3. Sequence models of syn-rift lacustrine basins

3.1 Identification of sequence boundary



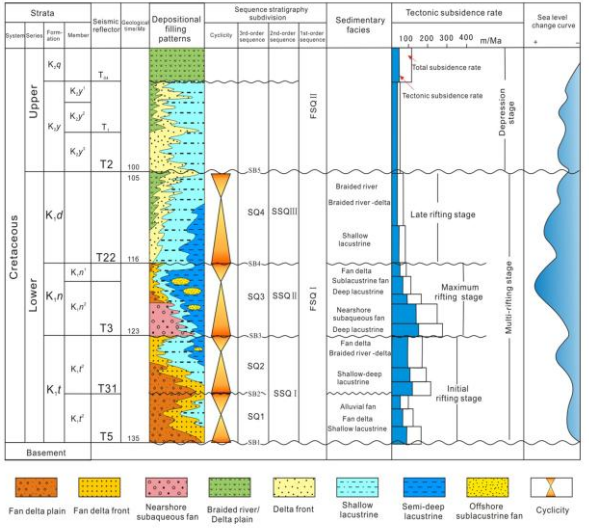


Seismic reflector termination patterns



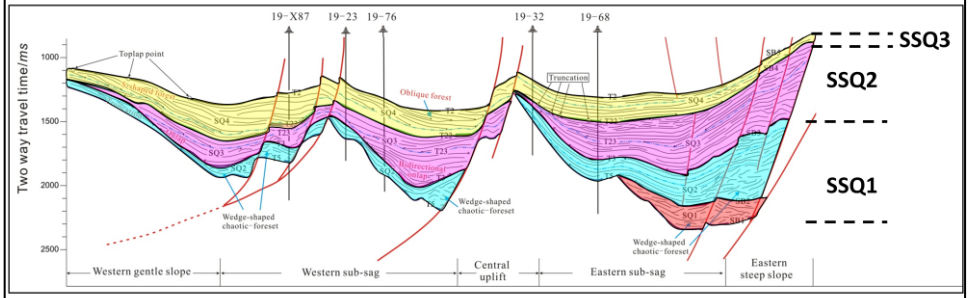
3. Sequence models of syn-rift lacustrine basins

3.2 Sequence classification and sequence models



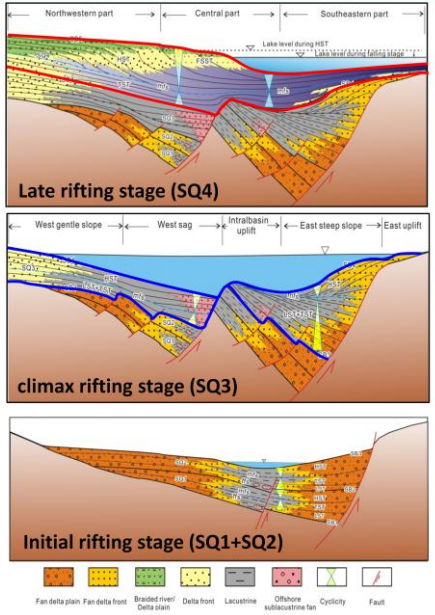
- One 1st-order SQ
- Three 2nd-order SQS
- Four 3rd -order SQS

3. Sequence models of syn-rift lacustrine basins



- Each 2nd -order sequence is corresponded with one episodic rifting
- Various sequence architectures (3rd -order)

3. Sequence models of syn-rift lacustrine basins



■ Depressional sequence

- ➢Decreasing subsidence to quiescence
- ➢Single long-axis provenance, braided river-delta- shallow lacustrine

■ Tectonic-rotational sequence

- ➢High subsidence rate
- ➢Rotation movement
- ➢Fan-delta, sublacustrine fan，deep lacustrine

■ Simple half- graben sequence

- ➢Low subsidence rate
- ➢Wedge-shaped geometry
- ➢Fan-delta, shallow lacustrine

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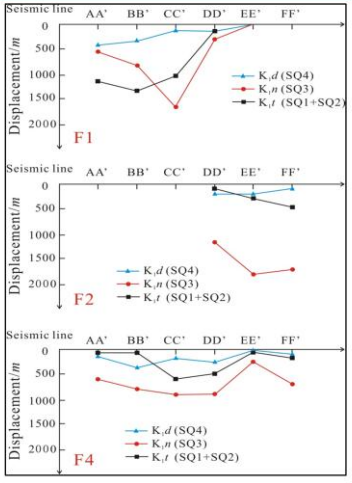
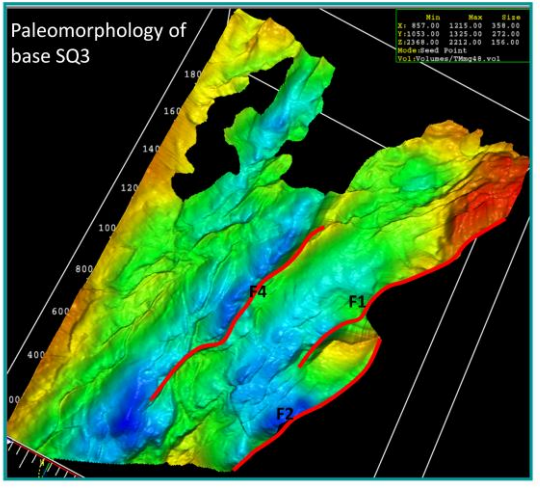
4. Tectonic controls on distribution of basin fills

5. Conclusions

4. Tectonic Controls on distribution of depositional systems and sand bodies in climax rifting stage (SQ3)





- Episodic rifting
- Various subsidence rate

paleomorphology

(1) Transfer zones

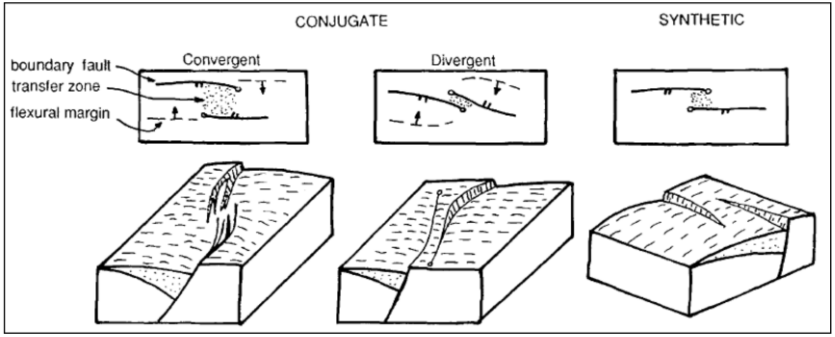
(2) Structural slope-break zones

4. Tectonic Controls on distribution of depositional systems and sand bodies in climax rifting stage (SQ3)

4.1 Transfer zones control the enter point of sediment influx

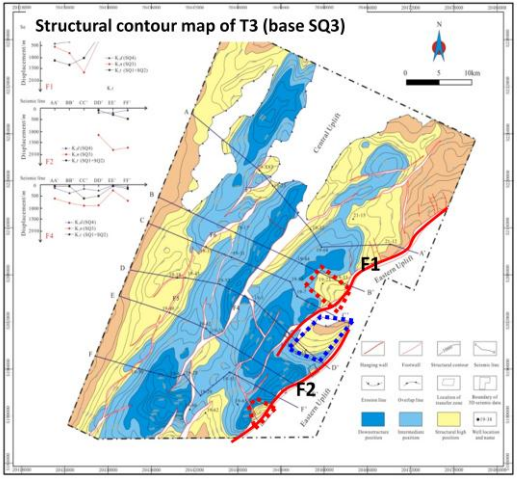
4.2 Structural slope-break zones control the distribution of depositional systems and sand bodies

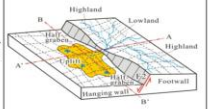
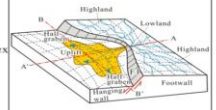
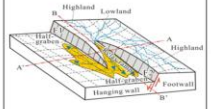
4.1 Transfer zones



Three main transfer zone geometries, simplified from Morley et al., (1990)

4.1 Transfer zones

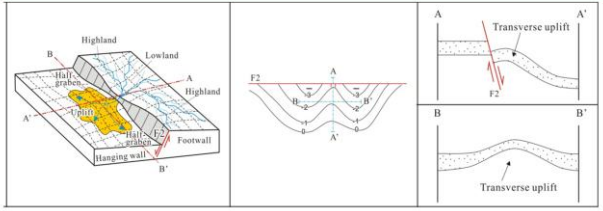


Type	Geometry		Block diagram of drainage system and sand bodies distribution
Synthetic approaching transfer zone	Transverse uplift	linear faults	
		Convex faults	
Synthetic overlapping transfer zone	Relay ramp		

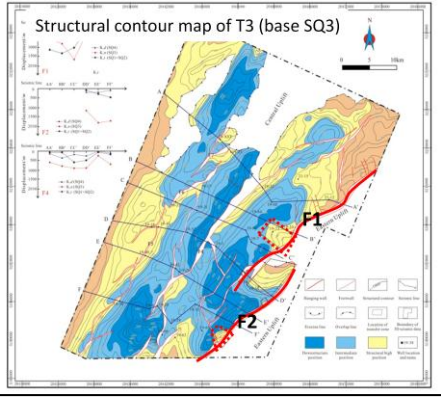
(1) Synthetic approaching transfer zone— transverse uplift

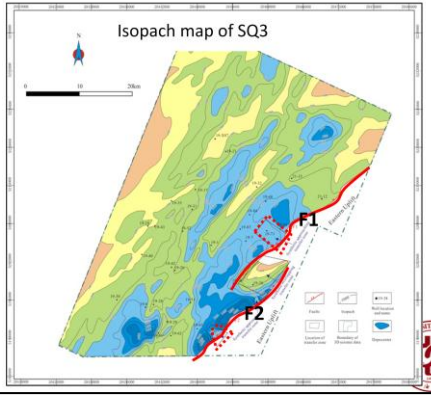
(2) Synthetic overlapping transfer zone— relay ramp

(1) Synthetic approaching transfer zone—transverse uplift

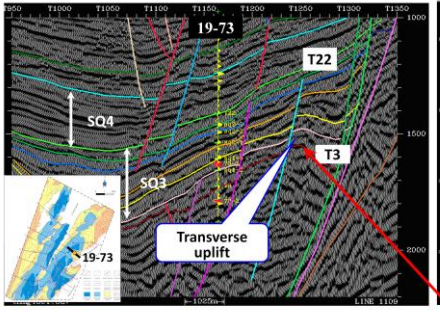


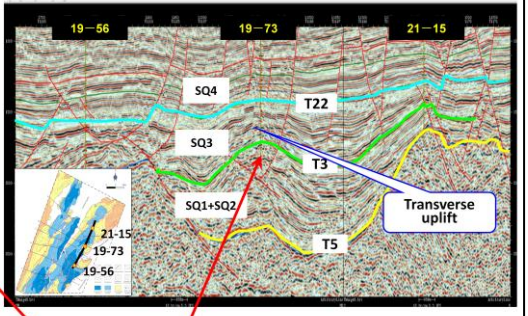
- Coordinate along-strike displacement change
- Paleohighs on the hangingwall
- Thinner strata

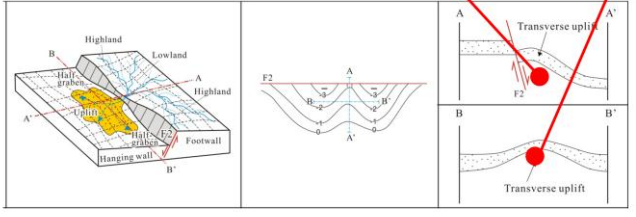




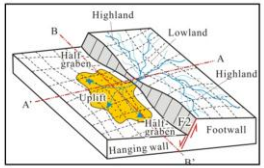
(1) Synthetic approaching transfer zone—transverse uplift

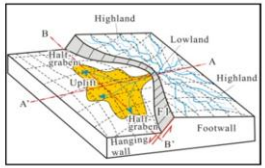




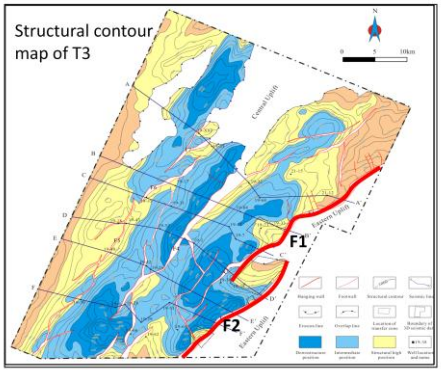


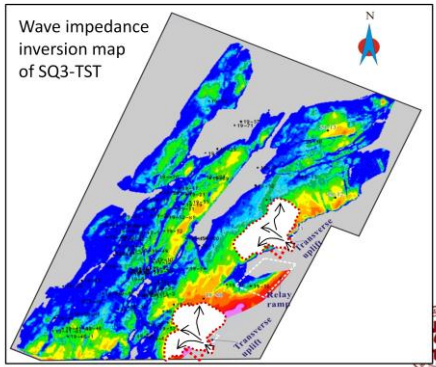
(1) Synthetic approaching transfer zone—transverse uplift



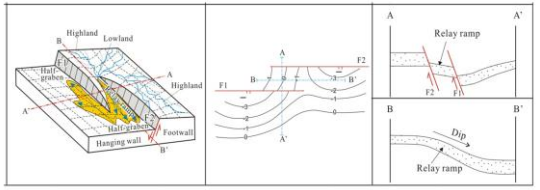


- Structural-low area on footwall
- Site for drainage catchment
- Enter points of sediment influx
- Sediments disperse round the uplift
- Fan-delta, subaqueous fans

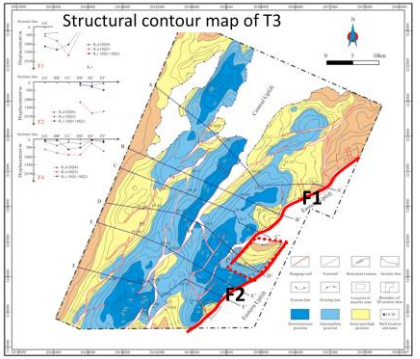


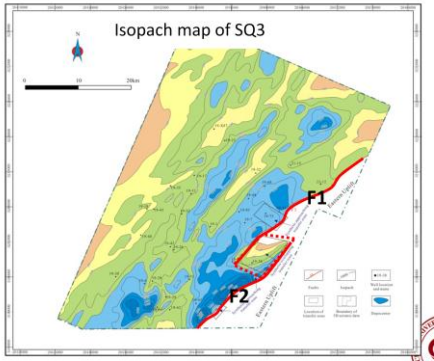


(2) Synthetic overlapping transfer zone——relay ramp

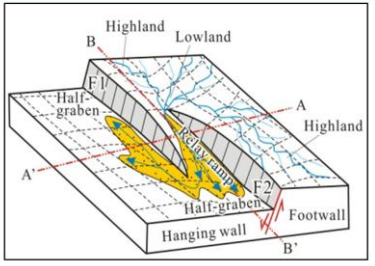


- Coordinate displacement of two overlapping faults (F1 and F2)
- Relay ramp
- Thinner strata

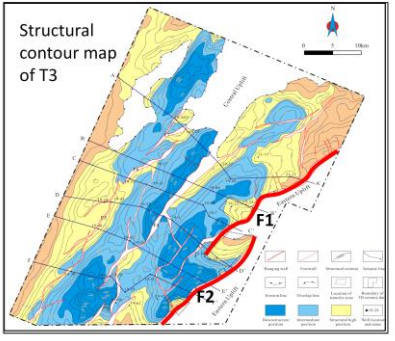


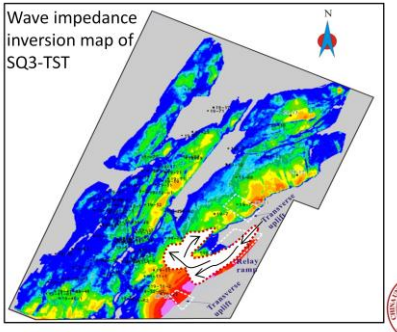


(2) Synthetic overlapping transfer zone——relay ramp

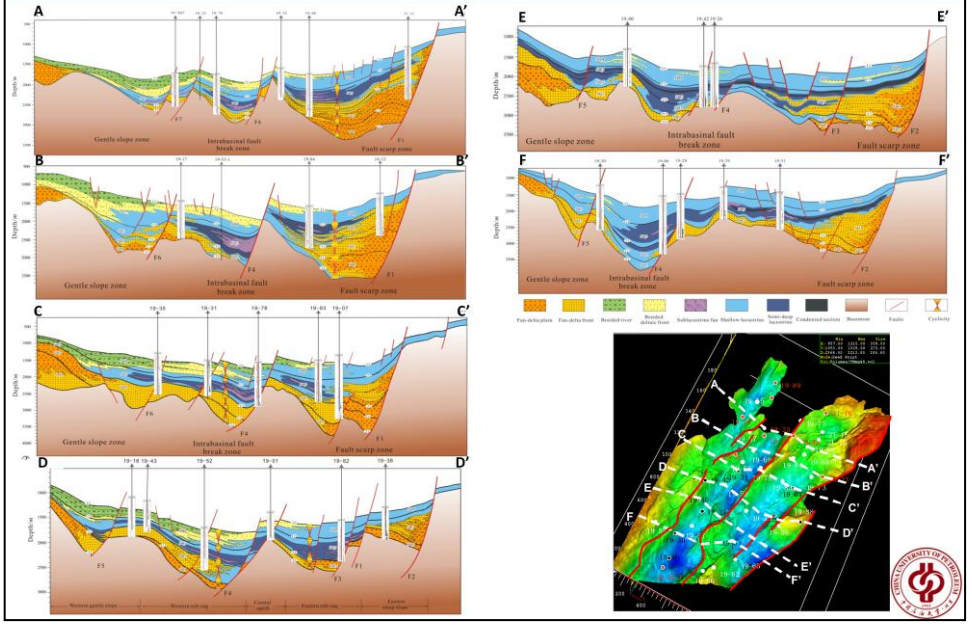


- Site for drainage catchment
- Enter points of sediment influx
- Sediments disperse along the ramp axis
- Fan-delta

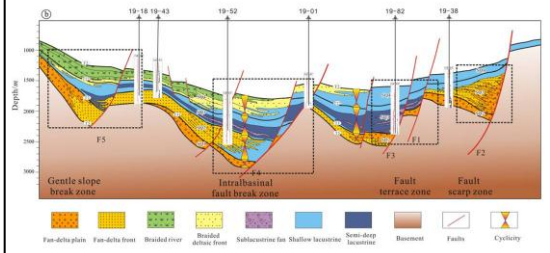




4.2 Structural slope-break zones control the distribution of depositional systems and sand bodies



4.2 Structural slope-break zones control the distribution of depositional systems and sand bodies



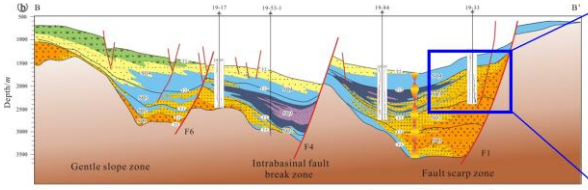
Types	Schematic diagram	Depositional systems	Examples
(a) Fault scarp zone		Fan-delta Nearshore subaqueous fan	Well 21-12 Well 19-07
(b) Fault terrace zone		Fan-delta Offshore sublacustrine fan	Well 19-82
(c) Gentle slope break zone		Fan-delta Braided river and braided delta	Well 19-18
(d) Intrabasinal fault break zone		Offshore sublacustrine fan	Well 19-78 Well 19-52

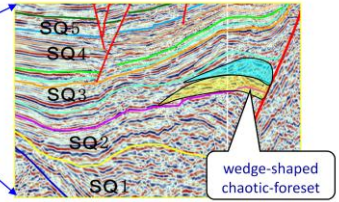
- Fault scarp zone
- Fault terrace zone
- Intralbasinal fault break zone
- Gentle slope break zone

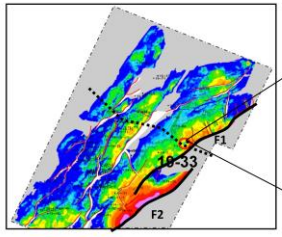
4.2 Structural slope-break zones control the distribution of depositional systems and sand bodies

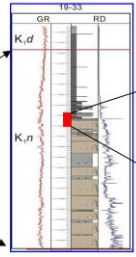
(1) Fault scarp zone and fan-delta

- Formed by F1 and F2, fault plane is steep and planar
- Adjacent to provenance
- Sediment mainly deposited as fan-delta depositional system
- Wedge-shaped geometry

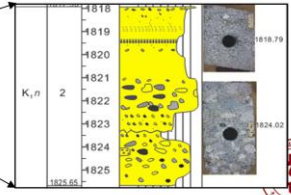








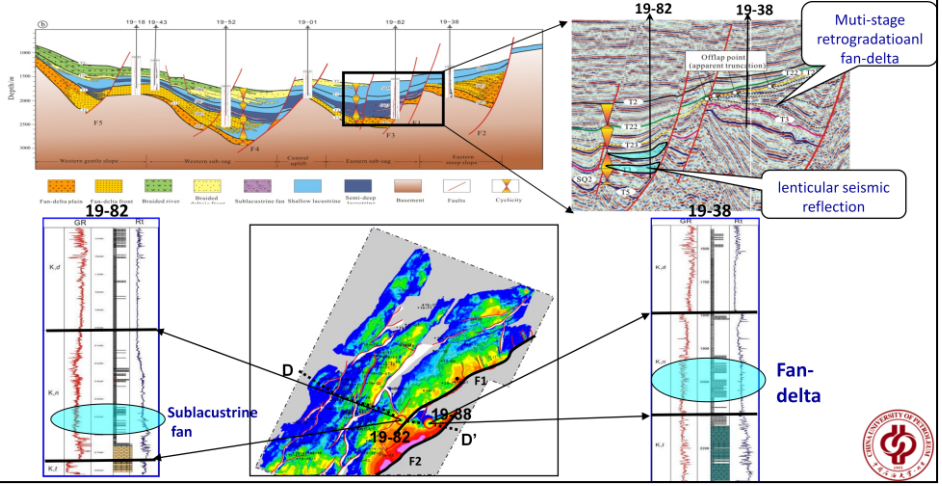
Fan-delta



4.2 Structural slope-break zones control the distribution of depositional systems and sand bodies

(2) Fault terrace zone and fan-delta & sublacustrine fans

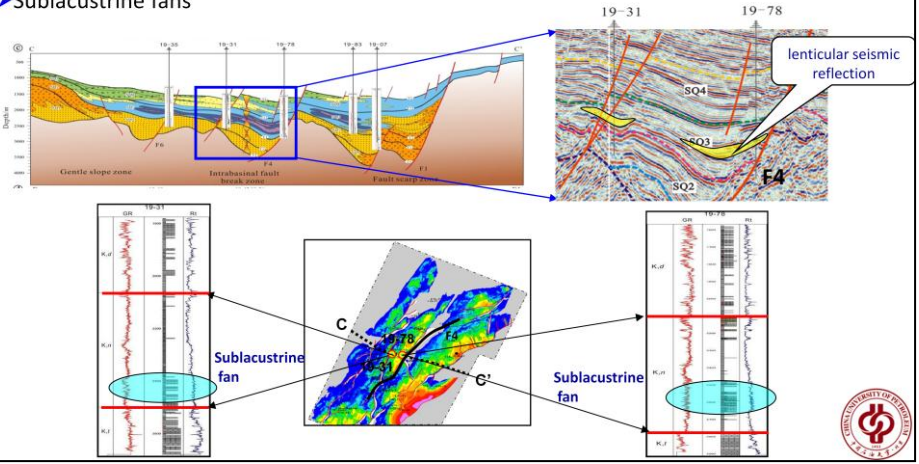
- Southern Tanan Depression
- Formed by F1 and F2, and their subordinate parallel faults
- Multistage step-fault flats
- Fan-deltas in the nearshore flat, sublacustrine fans in the offshore flat



4.2 Structural slope-break zones control the distribution of depositional systems and sand bodies

(3) Intralbasinal slope break zone and sublacustrine fans

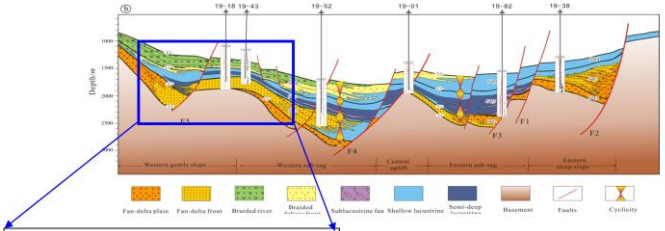
- Rotational movement of central fault F4
- Largest accommodation in the downthrown block
- Far from the provenance
- Sublacustrine fans

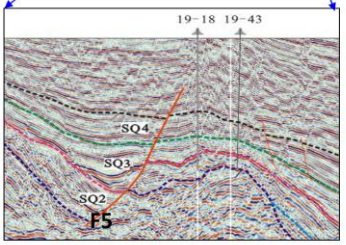


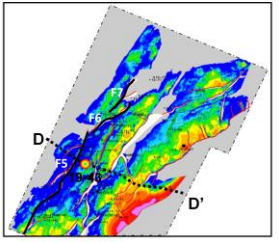
4.2 Structural slope-break zones control the distribution of depositional systems and sand bodies

(4) Gentle slope zone and braided river-delta

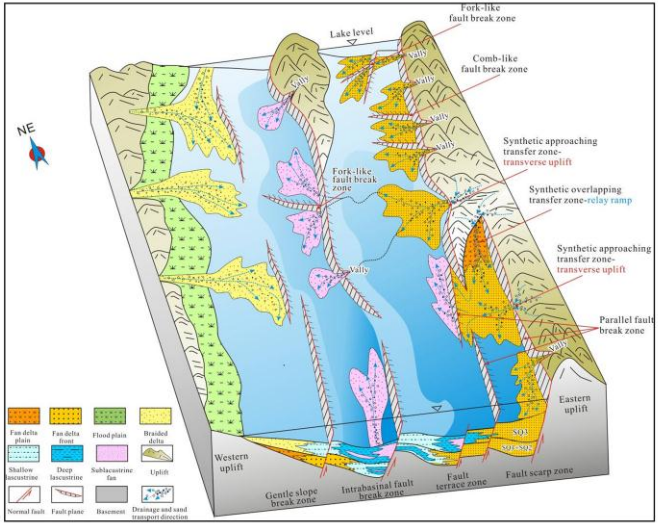
- Located in western slope area, antithetic fault terrace formed by F5,F6,and F7
- Sediment mainly deposited as braided delta in the slope margin





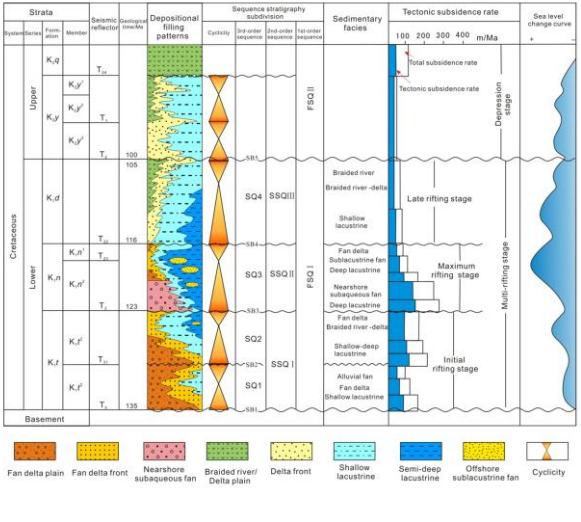


4.4 Tectonic controls on depositional systems and sand bodies in the climax rifting stage (SQ3)



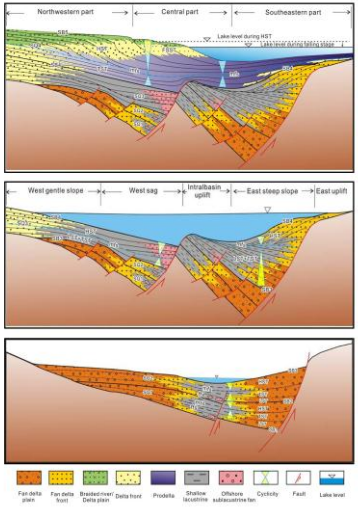
5. Conclusions

(1) The Lower Cretaceous in Tanan Depression could be subdivided into three 2nd-order sequences and four 3rd-order sequences.



5. Conclusions

(2) Three types of lacustrine sequences, consisting of distinctive depositional systems, was distinguished.



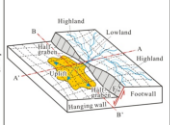
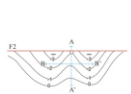
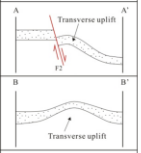
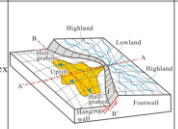
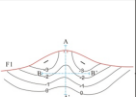
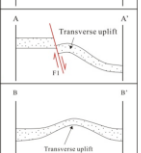
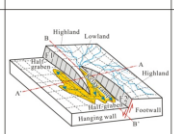
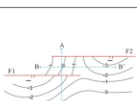
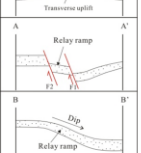
Depressional sequence

Tectonic rotation sequence

Simple half-graben sequence

5. Conclusions

(3) Transverse uplift transfer zone and relay ramp transfer zone were identified, and they controlled the entry points for sediments into the basin.

Type	Geometry		Block diagram of drainage system and sand bodies distribution	Schematic diagram of structural contour patterns	Schematic diagram of cross sections
Synthetic approaching transfer zone	Transverse uplift	linear faults			
		Convex faults			
Synthetic overlapping transfer zone	Relay ramp				

5. Conclusions

(4) Four types of structural slope-break zones were identified. The structural slope-break zones mainly influenced the distribution of depositional systems and sand bodies.