Sedimentary Characteristics and Controlling Factors of a Tight Sandstone Reservoir in the Upper Triassic Yanchang Formation, Southwest Ordos Basin, China*

Yi Gao[1]

Search and Discovery Article #11037 (2017)**
Posted December 26, 2017

*Adapted from oral presentation give at AAPG International Conference and Exhibition, London, England, October 15-18, 2017

[1]College of Energy Resources, China University of Geosciences, Beijing, China (gaoyi1232968@163.com)

Abstract

Ordos Basin is the second largest and the most productive oil- and gas-bearing basin in China. The Ch81 interval of the Upper Triassic Yanchang Formation is an important targeted reservoir in this basin. This tight sandstone reservoir is famous for its ultra-low permeability and high-production wells under water fracturing. For a long time, sandstones in this interval are interpreted to be deposited in a shallow water braided delta sedimentary system in the southwest of the basin. The thick-bedded channelized sandstones are well connected vertically and literally, and the reservoir quality is determined mainly by fault development condition. In this research, based mainly on core observation, description and analysis, we proposed that sediment gravity flow deposits are well developed in the study area in the southwestern Ordos Basin. There are four basic lithofacies assemblages: (1) thick-bedded sandstone with abundant lamination structures as channelized sandy deposits in braided delta; (2) thick-bedded chaotically contorted sandstone as sandy slump; (3) thick-bedded structureless sandstone as sandy debrite or high-density turbidite; (4) thin-bedded ripple cross-laminated sandstone as low-density turbidite. Based on core evidence of a sedimentary cross-section along flow direction with six cored wells, the most possible trigger of sediment gravity flow is delta-front collapse. Deltaic channelized sandstones are dominant in the proximal area. Sandy slumps are dominant in the middle area, which is formed by collapse of deltaic deposits and transform to high-density turbidite and sandy debrite in the distal area. Few low-density turbidite is shown. With additional geochemical evidence showing relative water depth, it can be determined that the study area is in a transitional environment in lacustrine basin between marginal delta and distal basin plain. In addition, the porosity and permeability data indicate that different types of deposits have varying reservoir quality, especially for permeability. As a result, reservoir quality is not only affected by fault development degree. Distinguishing high-permeability

sandstone is vital for oil-production in tight sandstone reservoirs. Therefore, this research sheds light on a new perspective based on delicate sedimentary research for future oil exploration and development in tight sandstone reservoirs in the most productive Ordos Basin.

Selected References

Amy, L.A., and P.J. Talling, 2006, Anatomy of turbidites and linked debrites based on long distance (120x30 km) bed correlation, Marnoso Arenacea Formation, Northern Apennines, Italy: Sedimentology, v. 53, p. 161-212.

Talling, P.J., D.G. Masson, and E.J. Sumner, 2012, Subaqueous sediment density flows: depositional processes and deposit types: Sedimentology, v. 59, p. 1937-2003.

Wang, M.L., Y.T. Liu, and F.D. Zhang F.D., 2015, Quantitative analysis of microscopic pore-throat structure of tight oil reservoir in Ordos Basin: Acta Mineralogica Sinica, v. 35/3, p. 318-322.

Zou, C.N., G.Y. Zhang, and S.Z. Tao, 2010, Geological features, major discoveries and unconventional petroleum geology in the global petroleum exploration: Petroleum Exploration and Development, v. 37/2, p. 129-145.

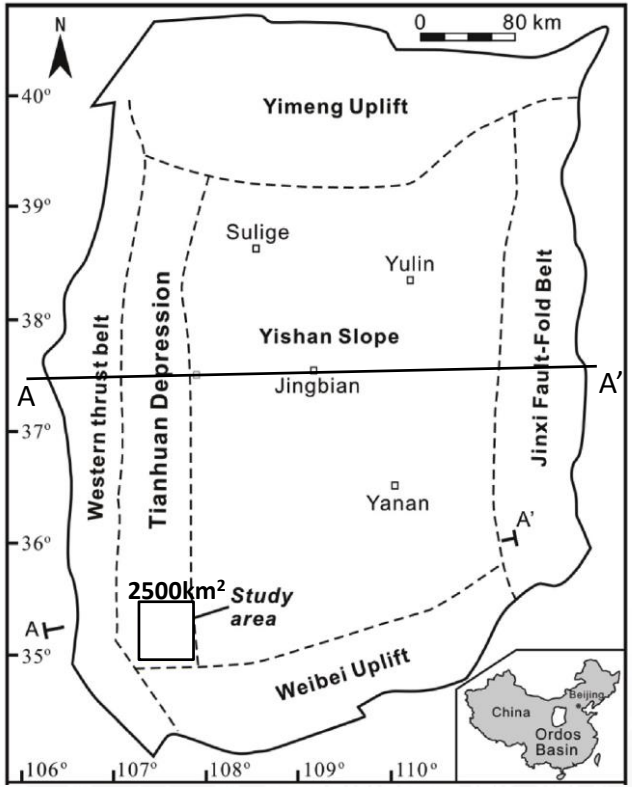
Sedimentary characteristics and controlling factors of a tight sandstone reservoir in the Upper Triassic Yanchang Formation, Southwest Ordos Basin, China

Yi Gao
China University of Geosciences

Outline

- **Background**
- **Major lithofacies assemblages**
- **Discussions**
  - Distribution of lithofacies assemblages
  - Depositional environment
  - Depositional model
  - Influence on reservoir quality

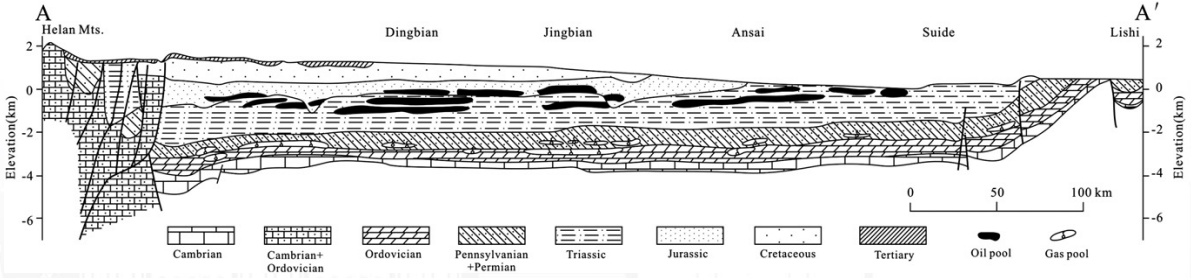
Geological setting



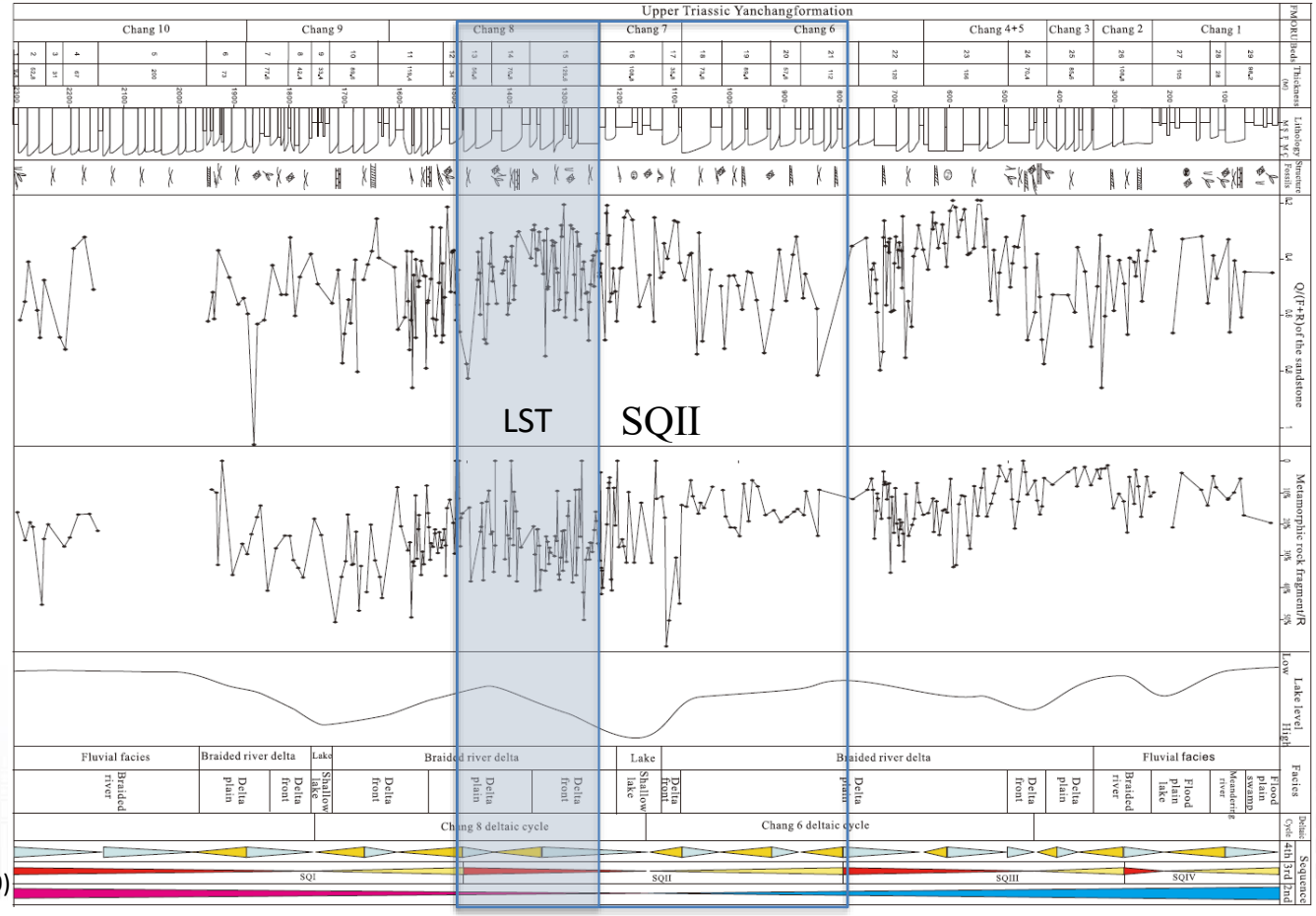
Epoch	Group/Formation
Quaternary	Loess
Pliocene	Laterite
Oligeocene	Qingshuying
Lower Cretaceous	Zhidan
Upper jurassic	Anding
Middle jurassic	Zhiluo
	Yan'an
Lower jurassic	Fuxian
Upper Triassic	Yanchang
Middle Triassic	Zhifang
Lower Triassic	Heshanggou
	Liujiagou
Upper permian	Shiqianfeng
Middle permian	Shihezi
Lower permian	Shanxi

Formation	Member	Thickness	Lithology
Yanchang	Chang 1	100-240	
	Chang 2	125-145	
	Chang 3	80-100	
	Chang 4+5	80-100	
	Chang 6	100-130	
	Chang 7	90-120	
	Chang 8	60-90	
	Chang 9	90-120	
	Chang 10	240-280	

$C8_1$

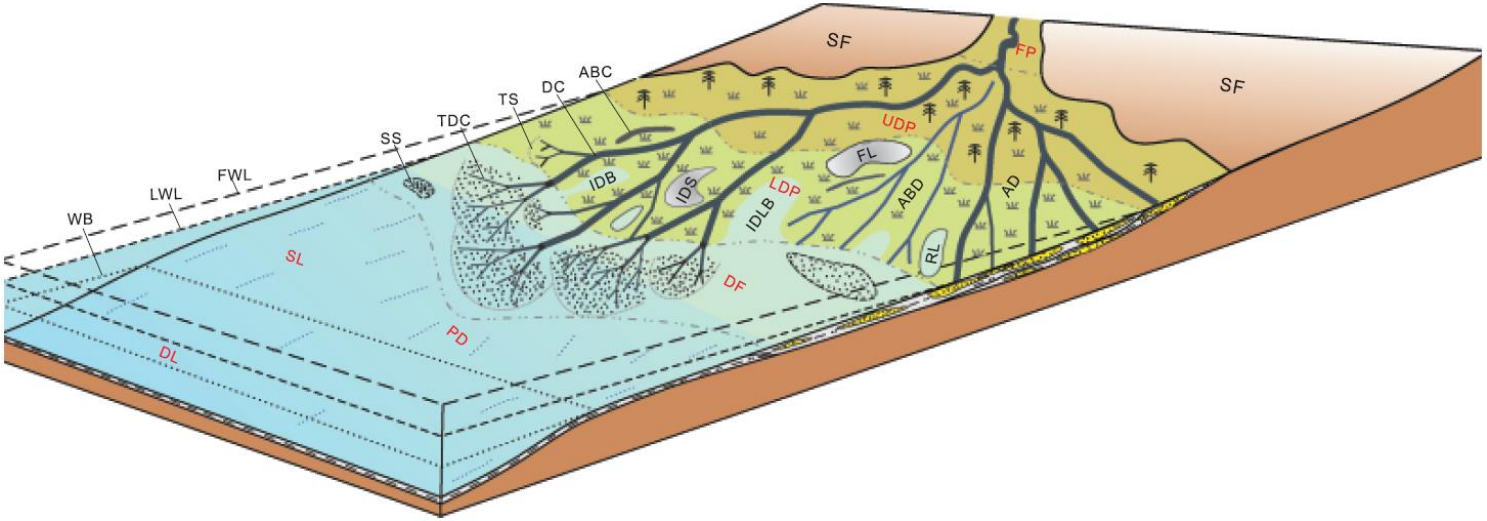


Sequence stratigraphic framework



(From Zou et al., 2010)

Existed depositional model

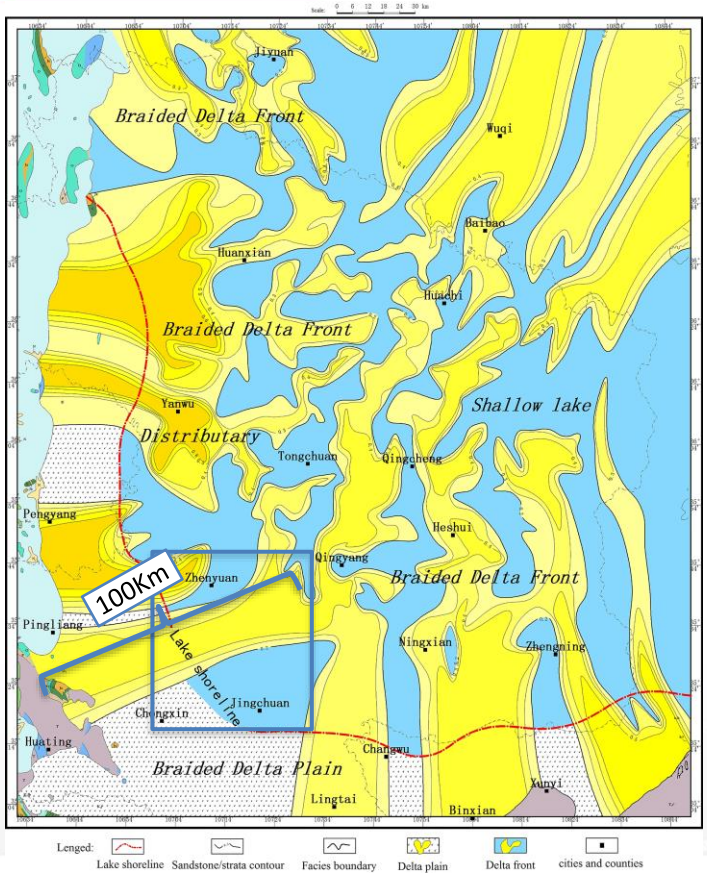


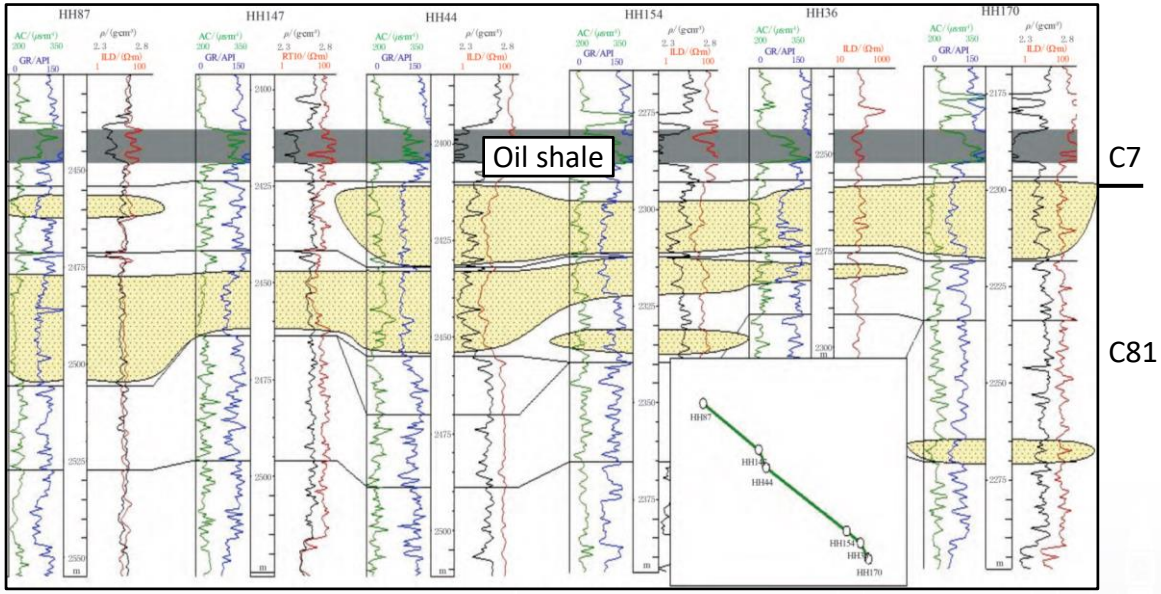
Shallow-lacustrine sand-rich braided river delta

Depositional model for river-dominated shallow-lacustrine delta. **ABC**, abandoned channel; **ABD**, abandoned delta; **AD**, active delta; **DC**, distributary channel; **DF**, delta front; **DL**, deeper lake; **FL**, food plain lake; **FP**, food plain; **FWL**, lake high-water level; **IDB**, inter-distributary bay; **IFLB**, inter-delta lobe bay; **IDS**, inter-distributary swamp; **LDP**, lower delta plain; **LWL**, lake low water level; **PD**, pro-delta; **RL**, residual lake; **SF**, substrate for cycle; **SL**, shallow lake; **SS**, sheet sand; **TS**, terminal splay; **TDC**, terminal distributary channel; **UDP**, upper delta plain; **WB**, wave base.

(From Zou et al., 2010)

Existed Sedimentary facies





(From Liu et al., 2015)

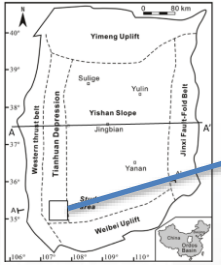
Outline

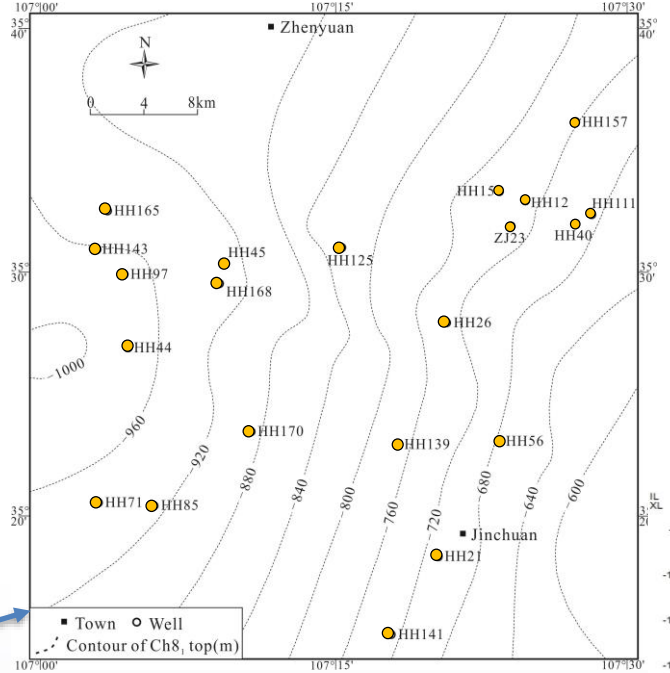
- Background
- Major lithofacies assemblages
- Discussions
  - Distribution of lithofacies assemblages
  - Depositional environment
  - Depositional model
  - Influence on reservoir quality

Database

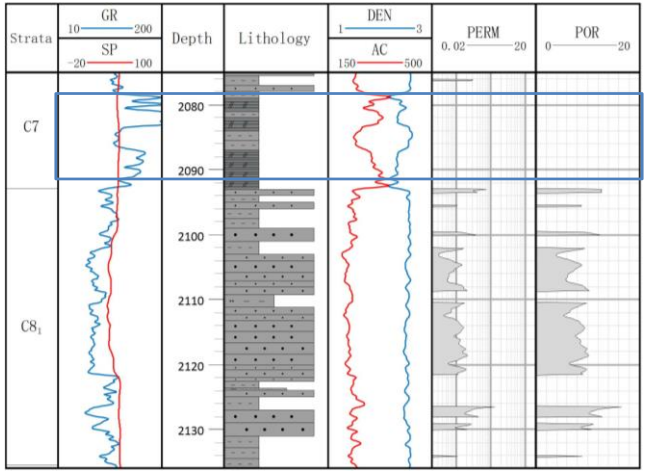
Mainly based on cores from more than 50 wells in the study area

- Log data
- 3-D seismic data
- Geochemical data



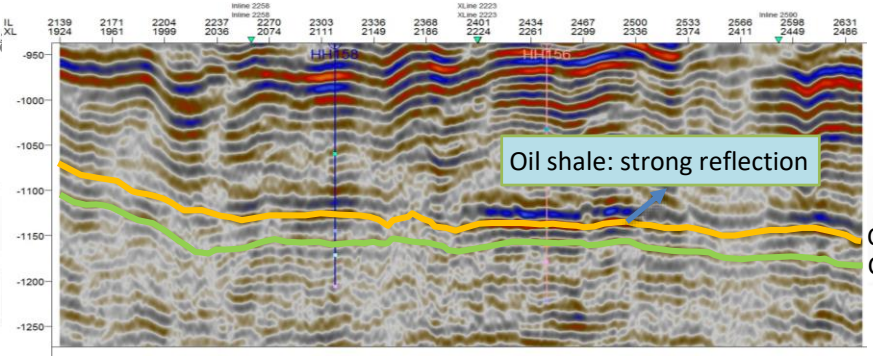


Identify the study interval



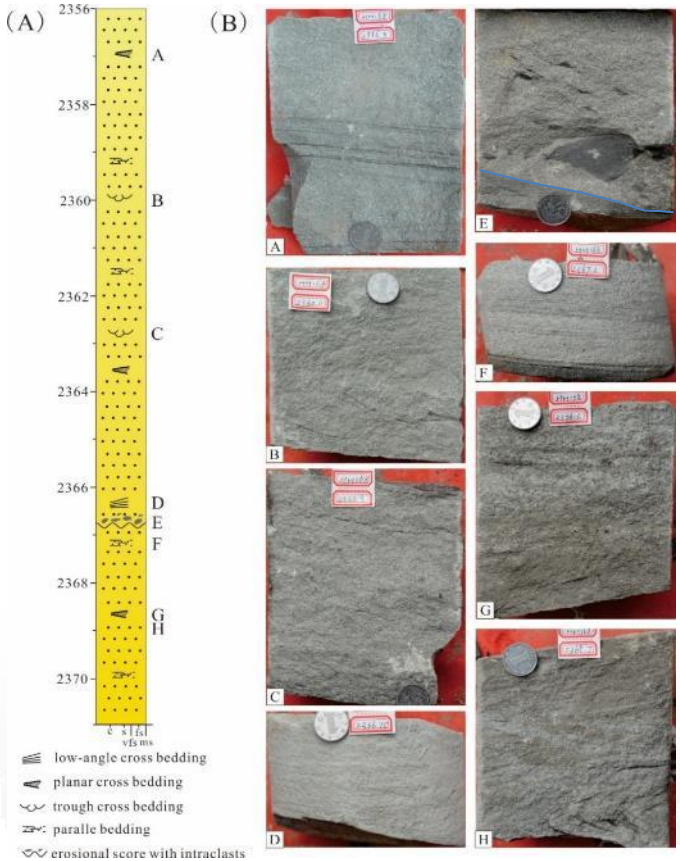
Oil shale

Below the C7 oil shale in the study area



Lithofacies assemblage

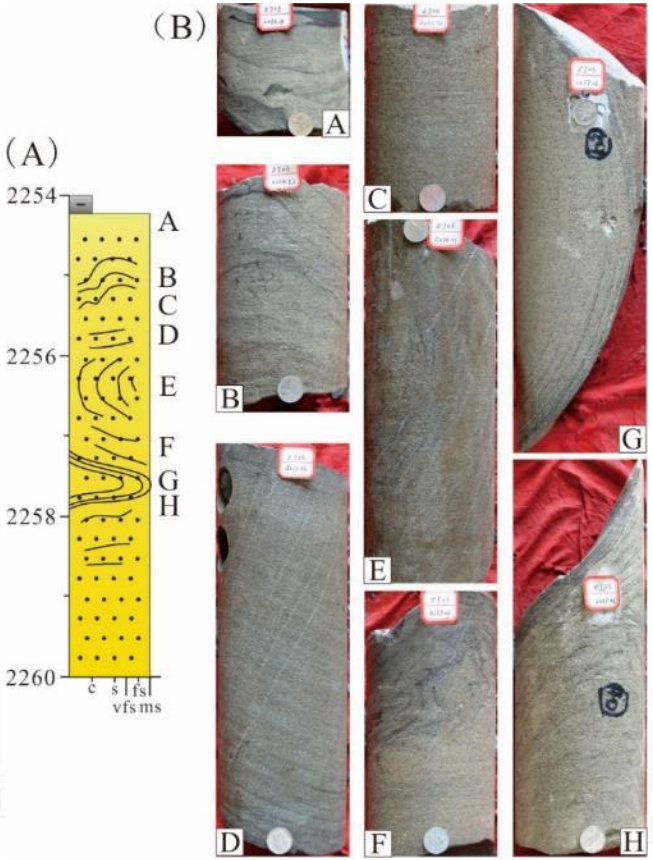
LA1



- *Description*
- *Interpretation*

Distributary channel deposits in braided delta

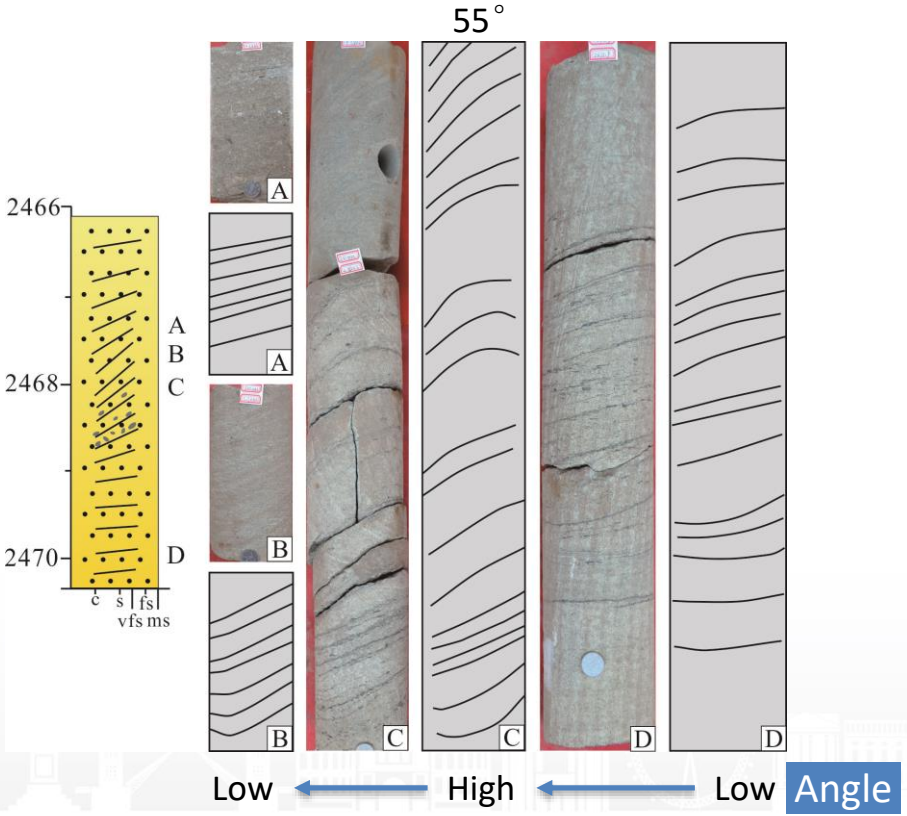
Lithofacies assemblage



LA2: Type 1

- *Description*
- *Interpretation*

Lithofacies assemblage

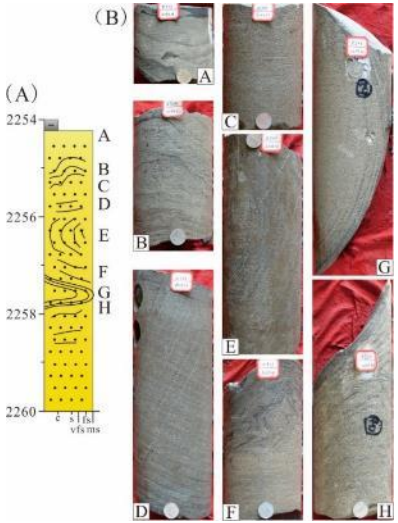


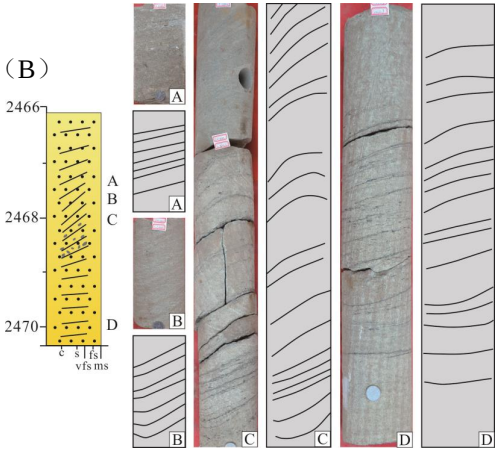
LA2: Type 2

- *Description*
- *Interpretation*

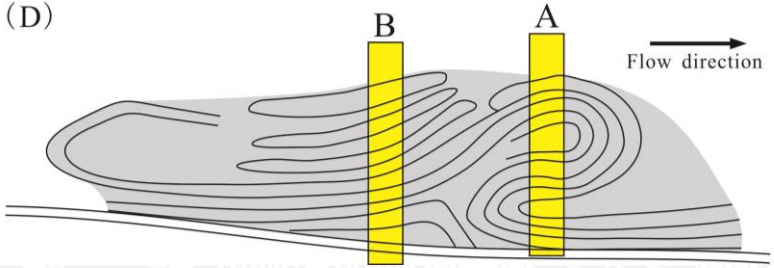
Lithofacies assemblage

LA2





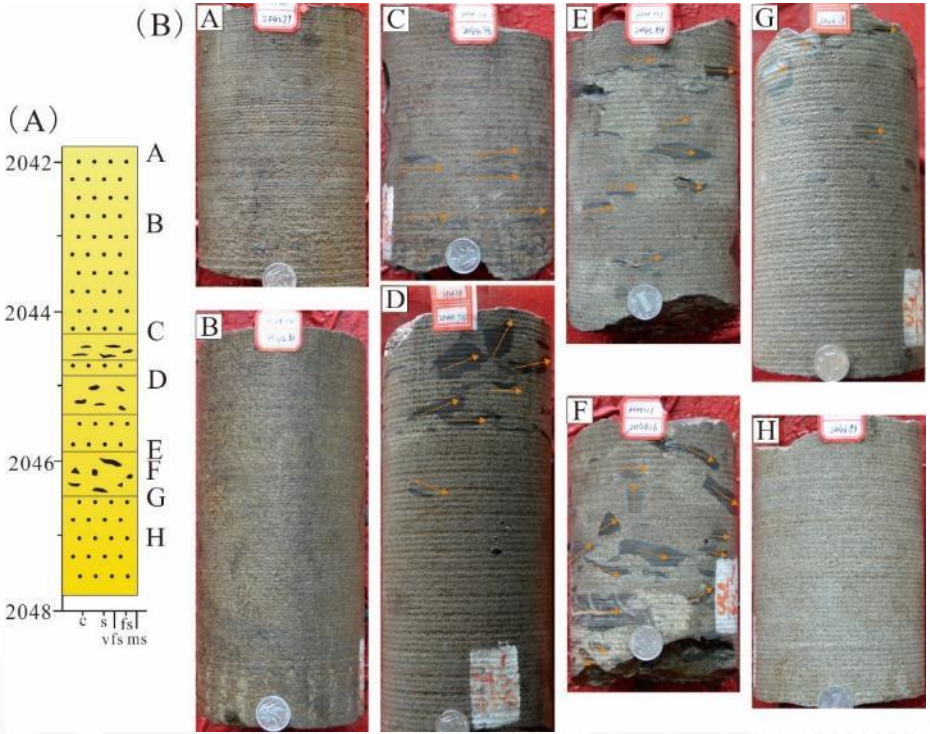
- *Description*
- *Interpretation*



Formation model

Sandy slump

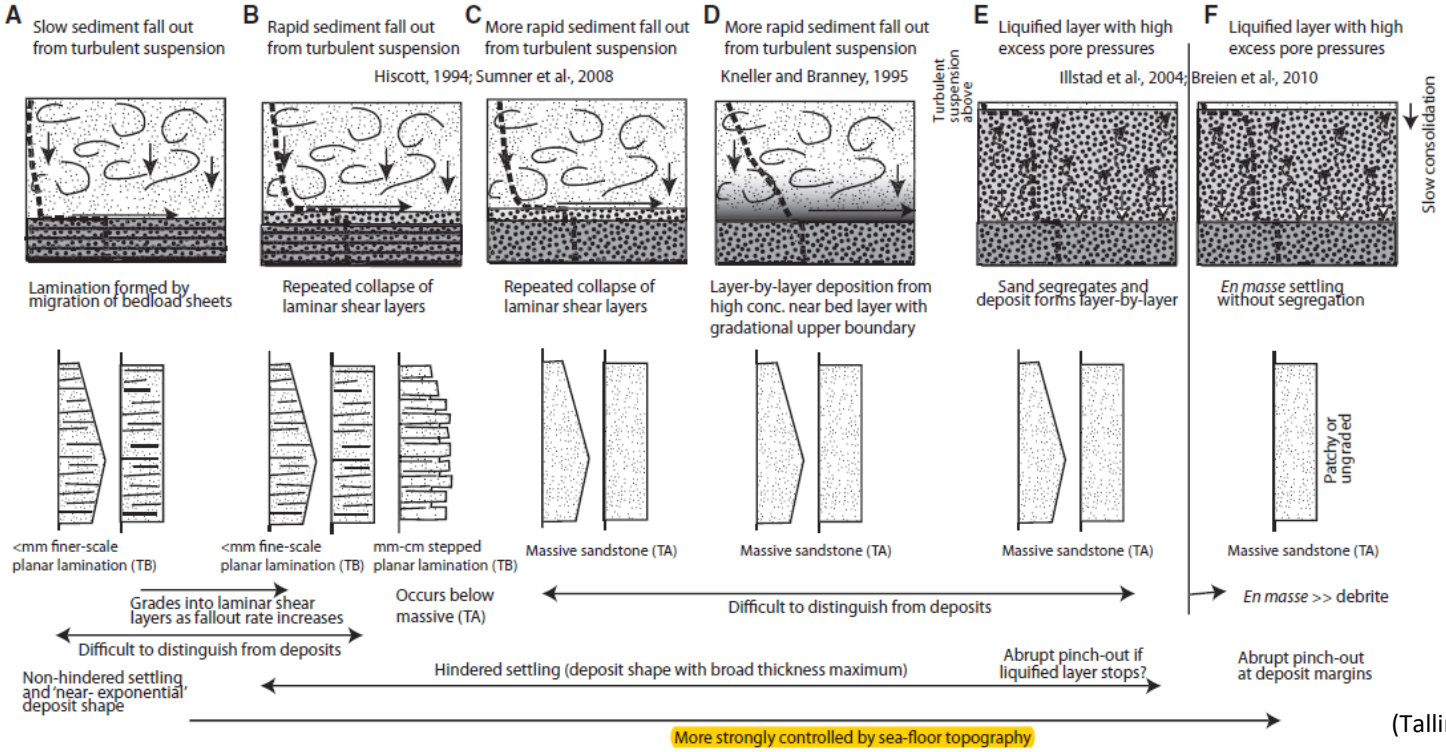
Lithofacies assemblage



LA3

- *Description*
- *Interpretation*

Lithofacies assemblage



(Talling et al., 2012)

- High-density turbidity current
- Sandy debris flow

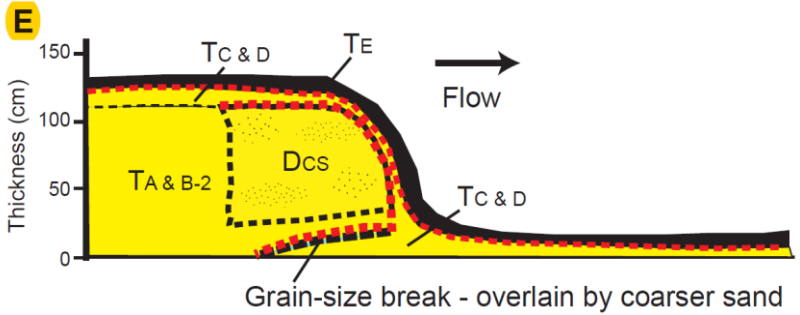
Summary of different processes that can potentially deposit planar-laminated or massive clean sand

Lithofacies assemblage

LA3

- *Description*
- *Interpretation*

Planar-laminated sandstone

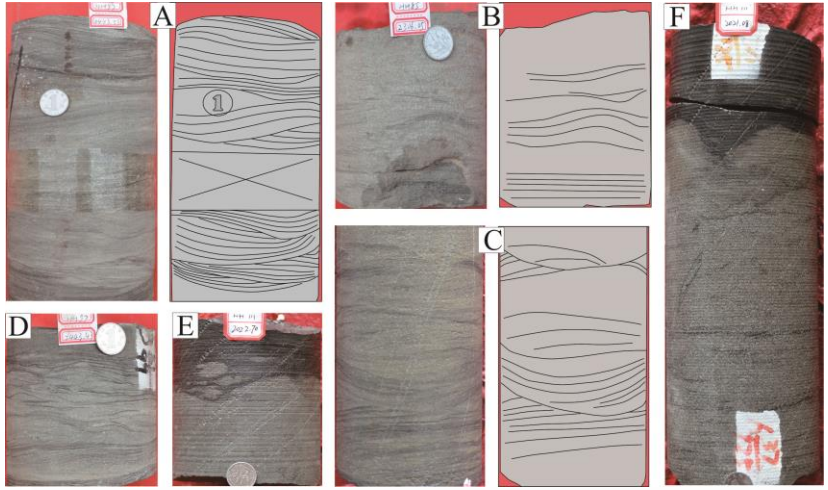


(Amy&Talling, 2006)

High density sediment gravity flow deposits

Lithofacies assemblage

LA4

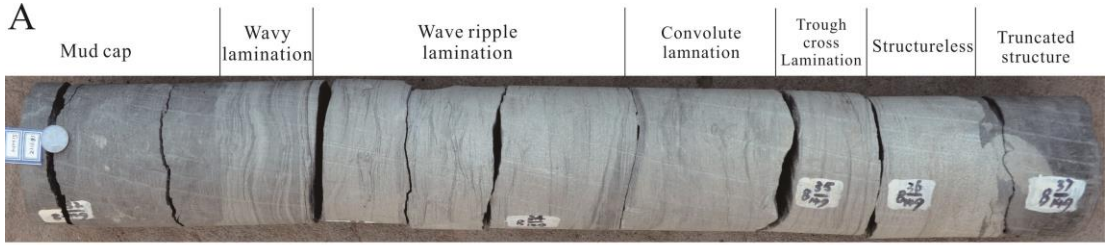


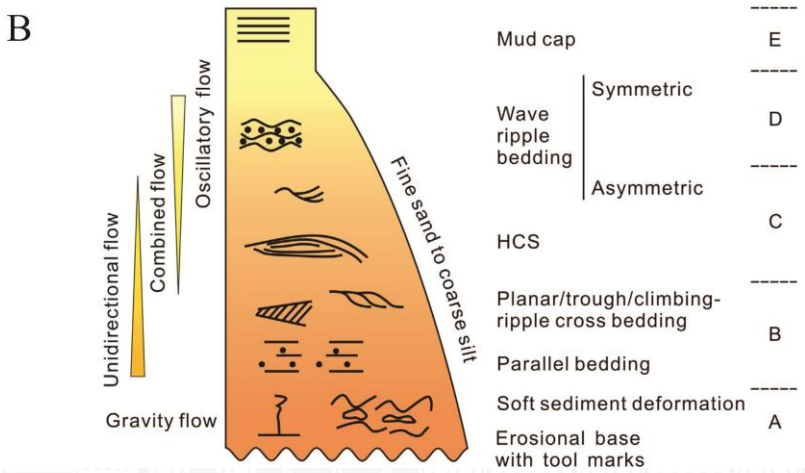
- *Description*
- *Interpretation*

Lithofacies assemblage

Complete lithofacies assemblage 4

LA4





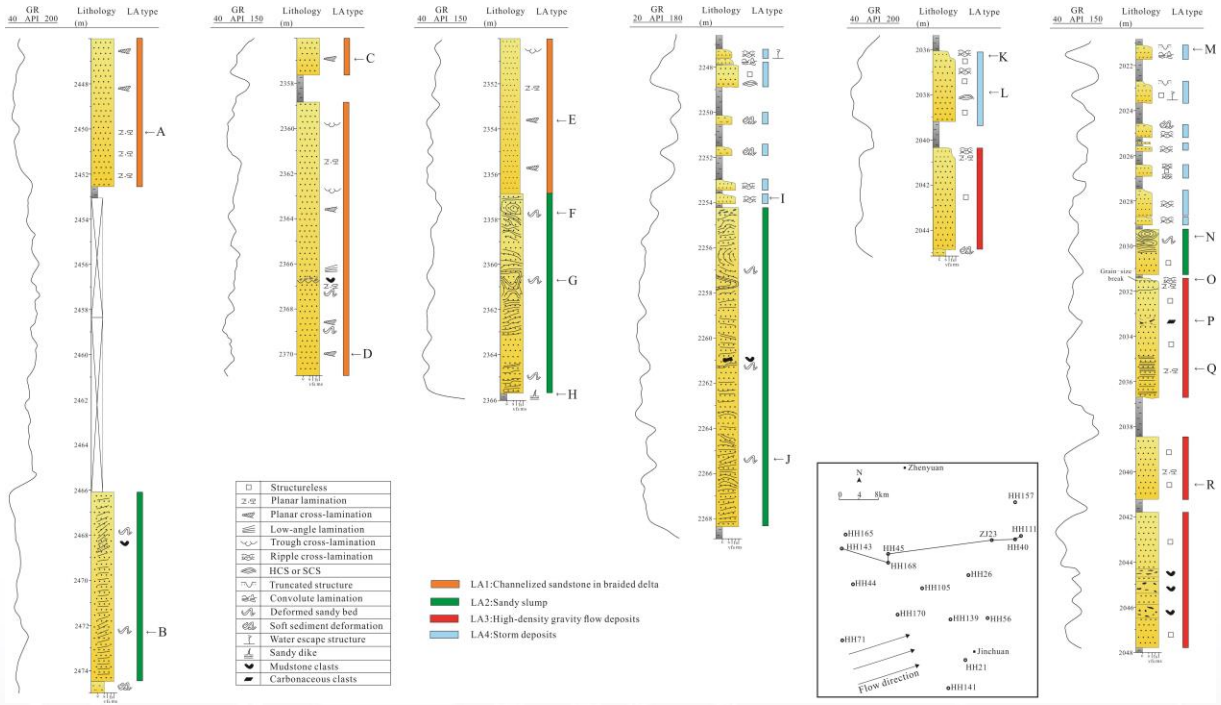
Storm deposits

Lithofacies association of lacustrine storm deposits (from Wang et al., 2015)

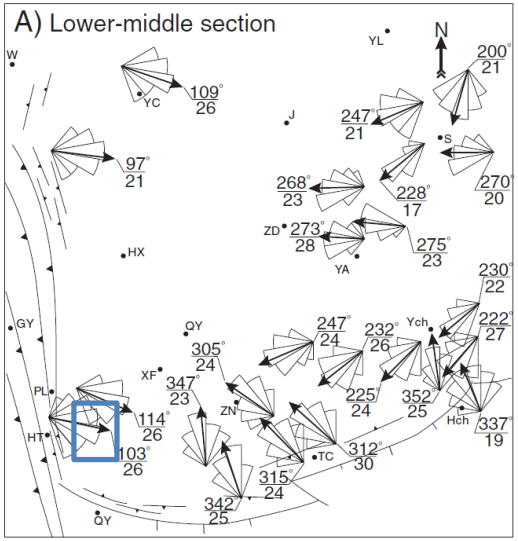
Outline

- **Background**
- **Major lithofacies assemblages**
- **Discussions**
  - Distribution of lithofacies assemblages
  - Depositional environment
  - Possible triggers of sediment gravity flow deposits
  - Influence on reservoir quality

Distribution of lithofacies assemblage



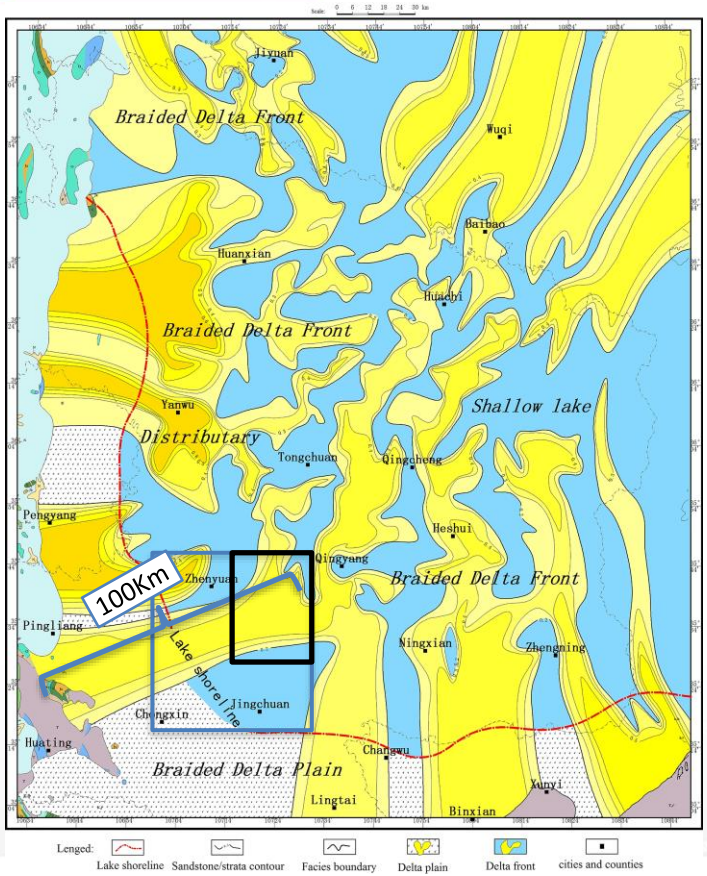
Sedimentary cross-section along paleocurrent direction with 6 cored wells

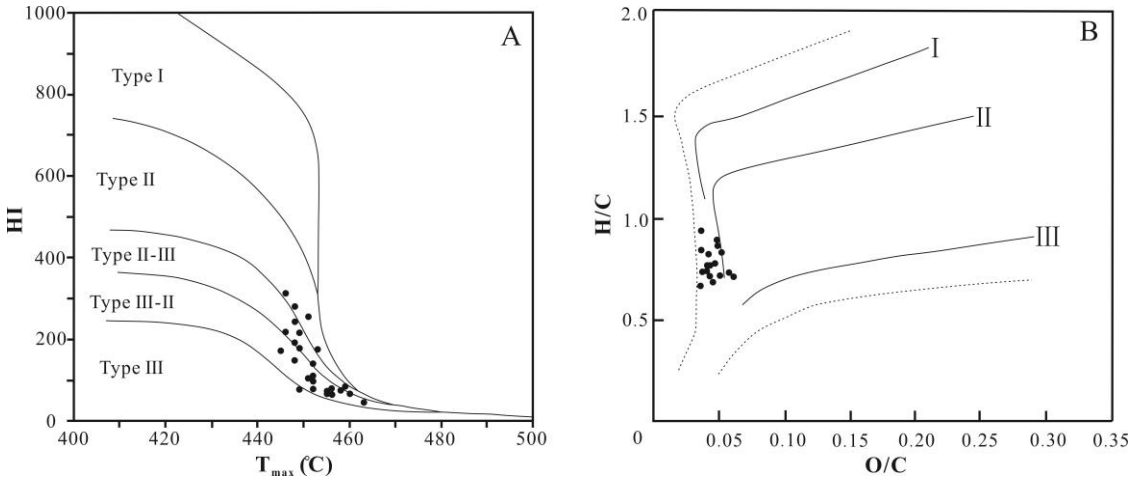


Paleocurrent measurement
(from Xie, 2016)

- LA1 and LA2 in the proximal area
- LA3 and LA4 in the distal area

Depositional environment

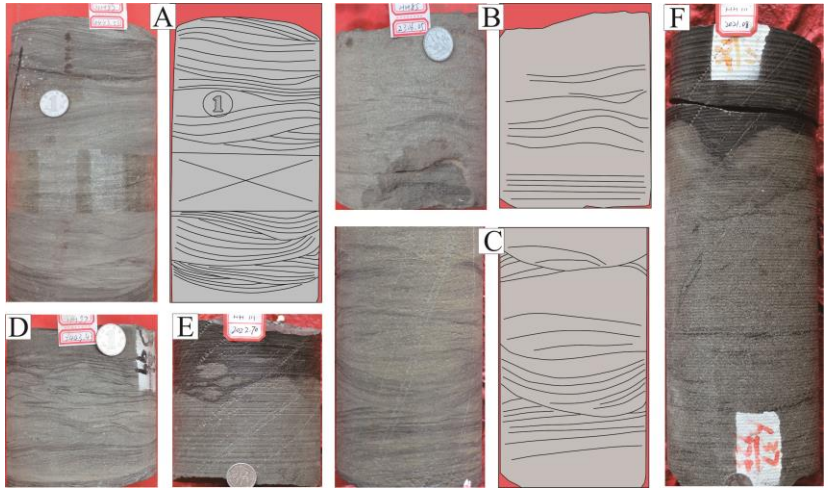




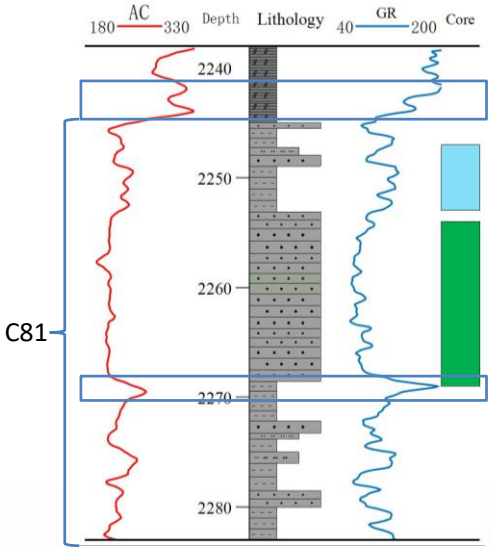
Plots of hydrogen index (HI) versus pyrolysis T_{max} (A) and atomic H/C versus O/C of kerogen (B) for mudstone in the $C8_1$ interval, showing the kerogen type

Possible triggers of sediment gravity flow deposits

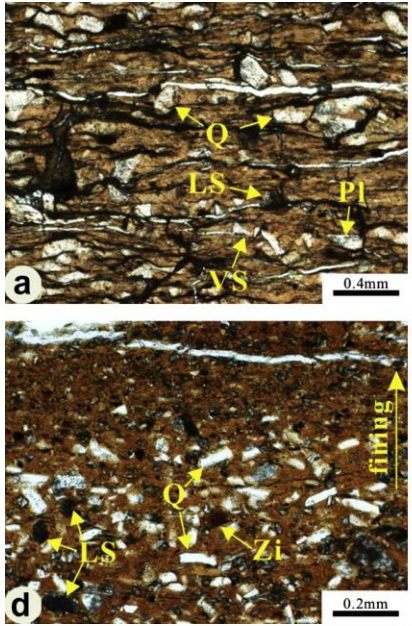
(Qiu et al., 2014)



Storm wave activity

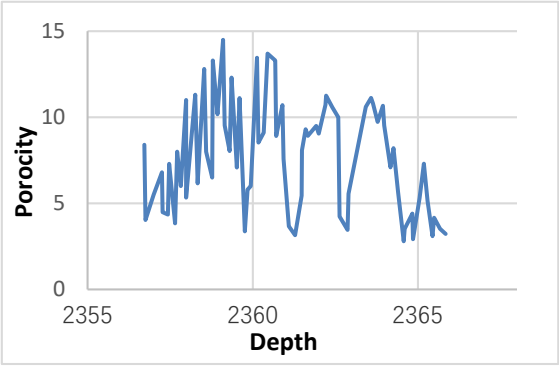


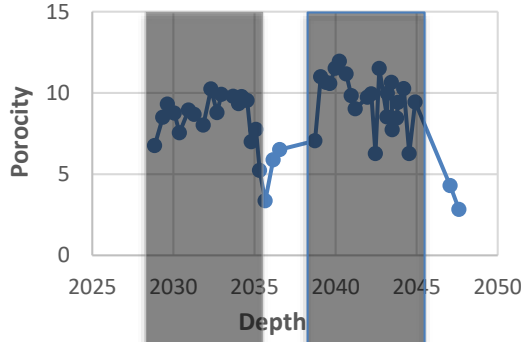
Volcanic activity

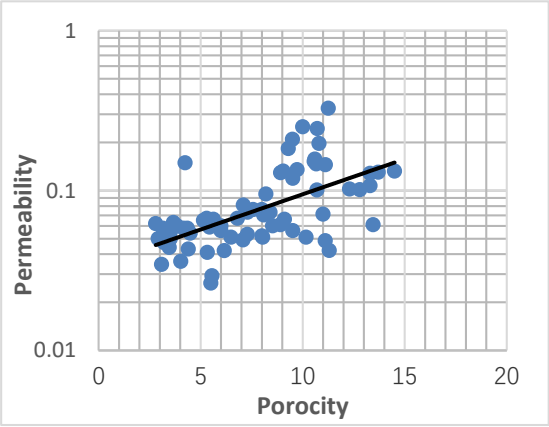


Tuff interval

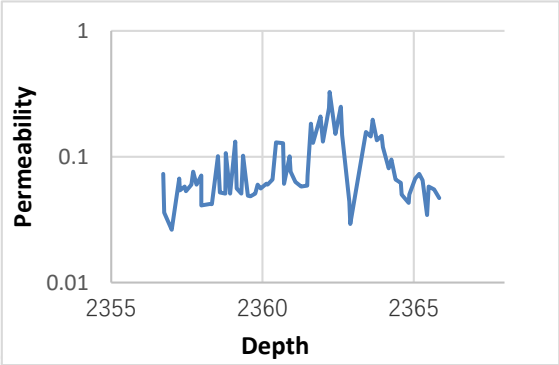
Influence on reservoir quality



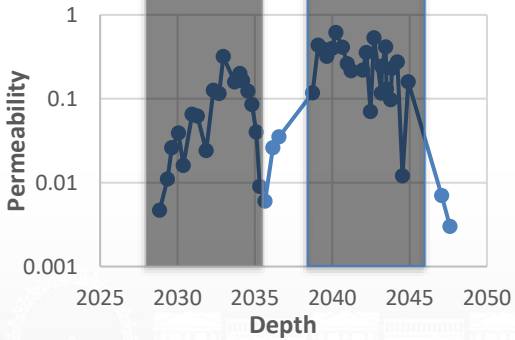




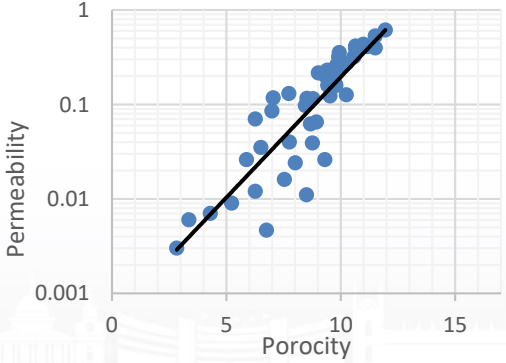
LA2



LA2

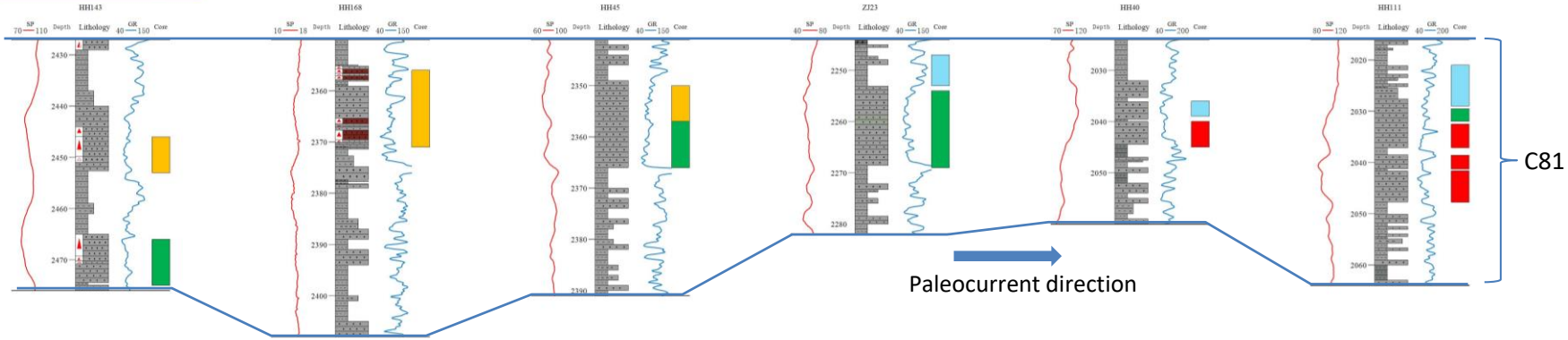


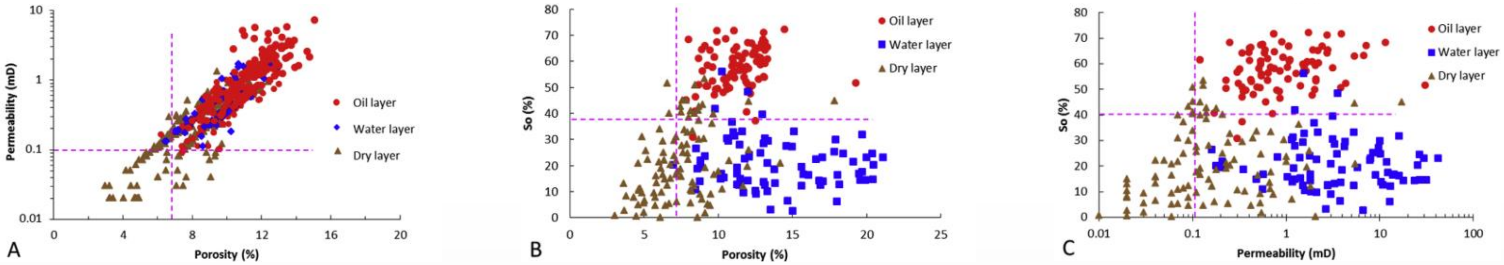
LA3



LA3

Influence on reservoir quality





Conclusion:

- The sandstone in the study area have different formation mechanisms
- Different types of sandstone have varying reservoir characteristics and reservoir property
- It is important to identify sandstone type accurately first for future oil exploration

Thank you!