

# **PS Seismic Geomorphology Application of Facies Models Analysis in Lobed-Channel System of Upper Miocene Huangliu Formation, Dongfang13-1/2 Block, Yinggehai Basin, China\***

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## **Abstract**

Three-dimensional seismic data have been widely used in interpreting ancient river systems and their associated sediment deposits. Thin-bed reservoirs of lobed-channel system in lithostratigraphic units of Dongfang (DF) area are one of the major study areas for reservoir growth in the Yinggehai Basin of northwestern South China Sea. Although it is understood that the transport mechanics of parent substrate and alluvium determine the morphology of a channel for lobed-channel system, the transport mechanism and regional gradient are relatively poorly understood. This study is focused on the application of various techniques in seismic geomorphology to the Yinggehai Basin to assess influences of regional gradient and relative sea level change on lobed-channel morphology. The Blue River delta received material from the western Vietnam Blue River drainage system during the Paleogene to Neogene. The gravity flow system in the DF areas has a close genetic relationship with the Blue River delta. In 3-D seismic survey area, four fifth-order sequences in the first member of upper Miocene Huangliu Formation were identified using well and seismic data. Seismic inversion and 90° phasing of seismic data were used to convert seismic traces to pseudolithologic logs. Stratal slicing made it possible to interpolate and extrapolate well-data-derived sequence and identify submarine fan, channel fill, lobes and overbank deposit. Strata slices suggested that sea-floor slopes exerted the main influence on channel morphology. Specifically, DF13-1 block had high gradient, which mainly distributed mud-sand-rich lobes. However, DF13-2 block established low gradient, which mostly indicated sand-rich braided channels. The values of sinuosity, channel widths, meander-belt widths in DF13-2 block are all greater than these in DF13-1 block. In addition, results of carbon isotope measurements and foraminiferal research of two blocks suggest that paleo sea level in DF13-2 block was higher than that of DF13-1 block. It also deciphered why channels in DF13-2 incised deeply because of the stronger hydrodynamic energy. Thus DF13-2 block was formed in a lobed-channel and sand rich system, compared with DF13-1 of channelized-lobes and mud-sand rich system.

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# Seismic geomorphology application of facies models analysis in Lobed-channel System of Upper Miocene Huangliu Formation, Dongfang 13-1/2 Block, Yinggehai Basin, China



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## Introduction

Three-dimensional seismic data have been widely used in interpreting ancient river systems and their associated sediment deposits. Thin-bed reservoirs in lithostratigraphic plays of lobed-channel system in lithostratigraphic units of Dongfang (DF) area are one of the major study areas for reservoir growth in the Yinggehai basin of Northwestern South China Sea. Identifying and predicting thin bed reservoirs is one of the difficulties and hot spots of hydrocarbon exploration in China. Although it is understood that the transport mechanics of parent substrate and alluvium determine the morphology of channel for lobed-channel system, the transport mechanism is relatively poorly understood. This study is focused on the application of various techniques in seismic geomorphology to the Yinggehai Basin at paleo-water-depth of 90m~120m to assess influences of regional gradient and relative sea level change on lobed-channel palaeogeomorphology in shallow-water environments.

Yinggehai Basin is a Cenozoic petroliferous basin developing in the western region of the Northern South China Sea continental shelf (Fig 1). In the Central depression of Yinggehai Basin, a large nearly-NS trend and echelon arrangement mud-fluid diapir structure is developed in groups and zones, which is collectively referred to as the Central Diapir Zone. The study areas, DF 13-1/2 blocks are located in the southwest of mud diapir structure zone in the central depression. The lobed-channel system is mainly developed in the Low stand systems tract (LST: T31-T301).

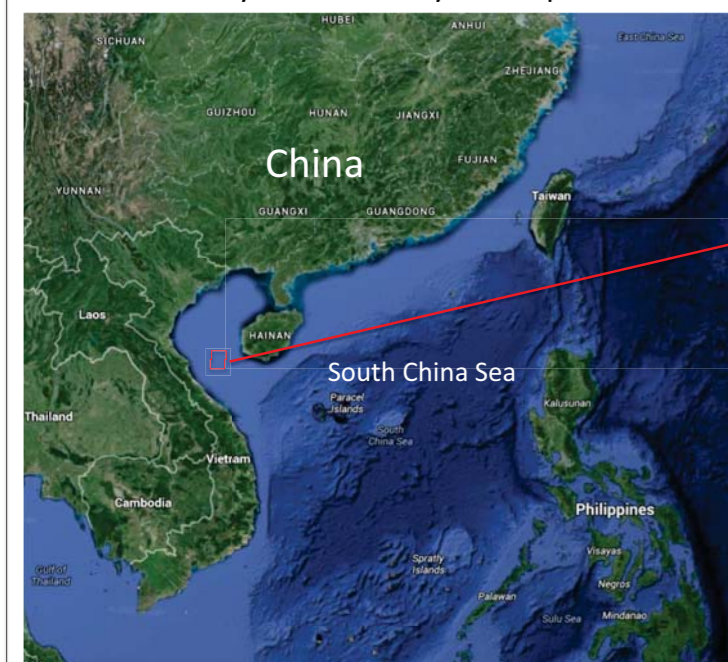


Fig 1. Map showing geographic location of the Dongfang (DF) blocks, outline of two 3-D surveys (shown as red line)

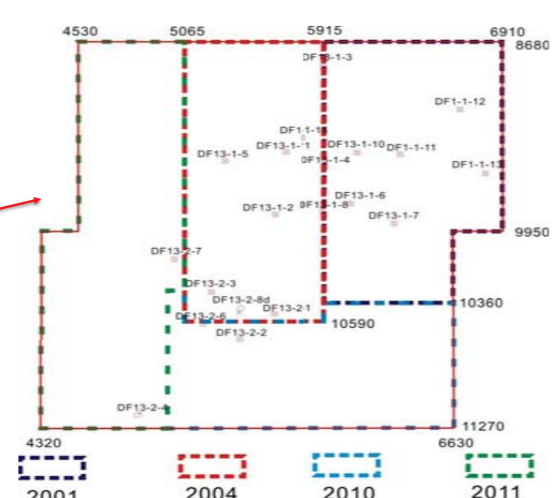


Fig.2 Distribution of Poststack seismic data from Year 2001, 2004, 2010 and 2011 (location of study areas showing in Figure1) and well distribution (shown as black dots).; purple=Year 2001; red=Year 2004; blue=Year 2010; green=Year 2011.

## Methods

In 3D seismic survey area, four fifth-order sequences in first member of Huangliu formation (Between T30 and T31) are identified in an interval using well and seismic data.

The five steps of seismic data processing are:

- Seismic inversion and 90° phasing convert seismic traces to pseudolithologic logs (Figure 3).
- Seismic sequence boundaries T301 and T31 are chosen as the frequency independent seismic events after frequency division processing from 35HZ to 55HZ.
- Rock-physics relationship analysis: sandy sediment are statistically low in acoustic impedance value compare with muddy sediment (Figure 4).
- Stratal slicing makes it possible to interpolate and extrapolate well-data-derived sequence and identify submarine fan, channel fill and lobes.

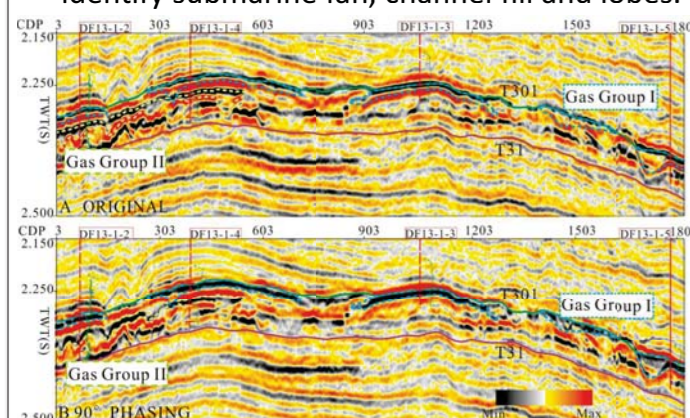
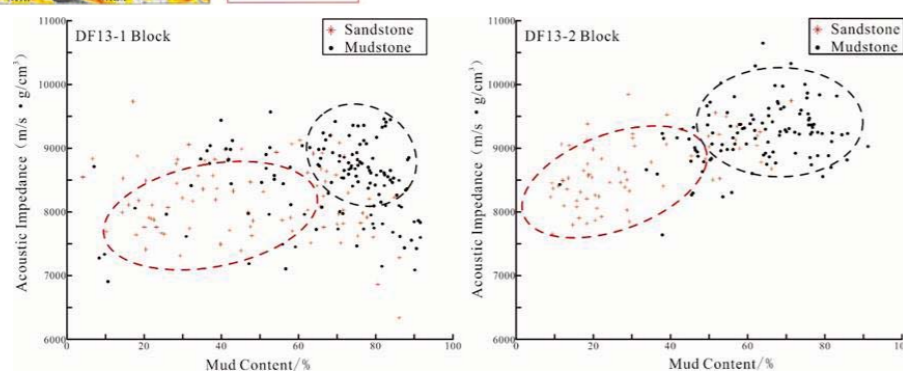


Fig 3. Original and 90° phasing seismic profiles of gas group I and II in DF13-1/2 blocks: In the original seismic section, the top and bottom surface of I and II gas group are respectively tied to seismic trough events (black) and seismic peak events (red). In the reprocessed seismic section, almost all the sandstones in the wells are tied to seismic trough events (black) with minimal ambiguity.

Fig. 4. Rock-physics relationship analysis for Neogene sediment, DF13-1/2 blocks. The cross-plot of acoustic impedance and mud content (20 wells). Acoustic impedance was calculated from density logging curve (RHOB) and acoustic time difference curve (DT), and mud content if from natural gamma ray logging curve (GR).



## Results

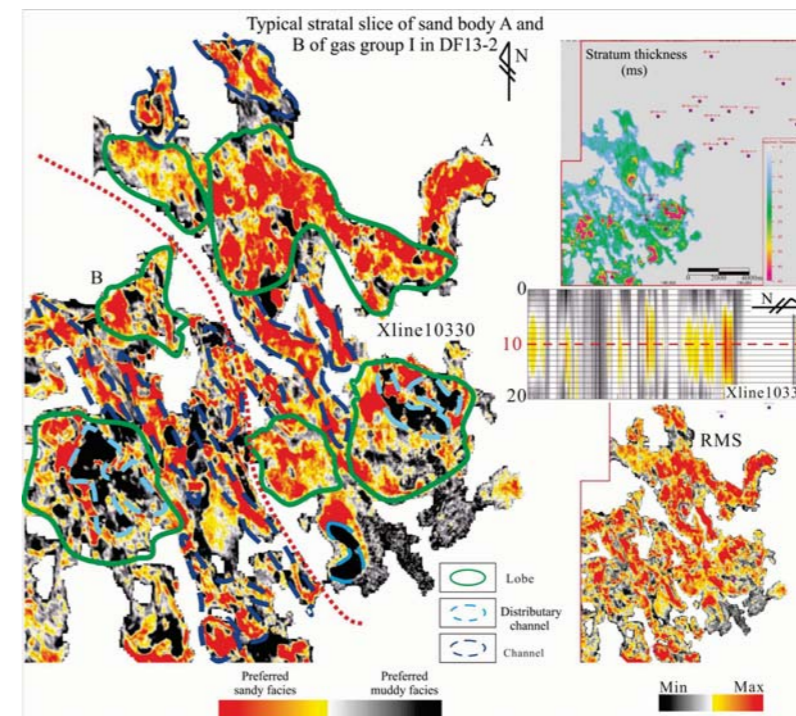
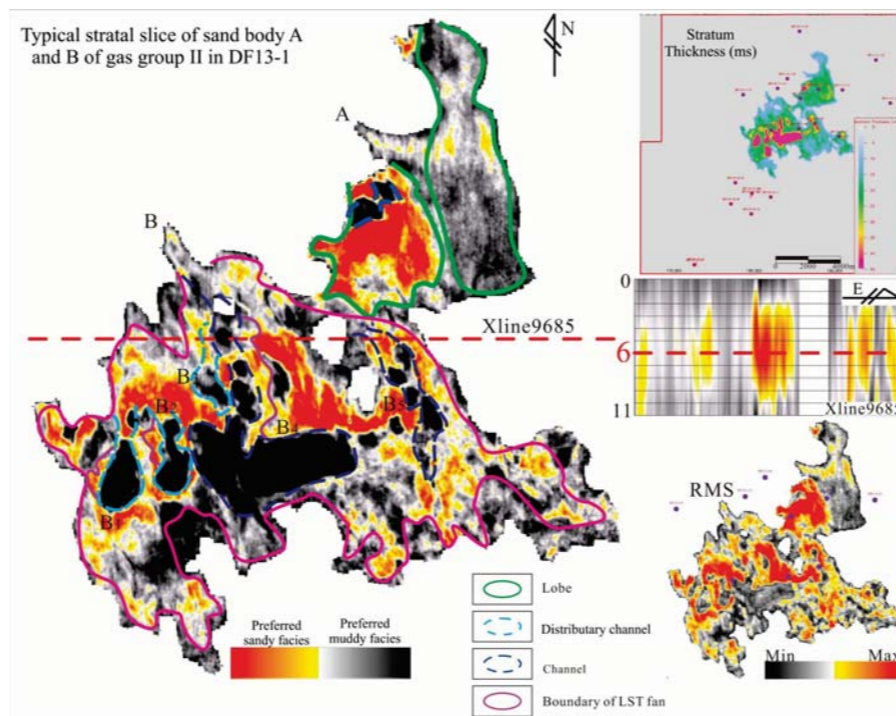


Fig.5 Comparison of stratal slices for seismic amplitude attribute from gas group II in DF13-1 block (left) and DF13-2 block (right). DF13-1 block shows multi-lobes formed inside the low system tract fan. B1, B2 and B3 are the distributary channels and B4, B5 are the main channels; DF13-2 block shows liner channels.

- DF13-1 Block seismic facies: Eastern part of Sand Body A (SB\*A=sand body A) show linear black amplitude and RMS value is relative lower, which represents muddy lobes. Distributary channels B1, B2, B3 are straight and shallowly incised. But main channel B4 are highly sinuous, architecturally complex, and deeply incised.
- DF13-2 Block seismic facies: SB\*A gradually shows linear red negative amplitude to fan-shape red negative amplitude, which respectively correspond with channels to sandy lobes from North to South. And multi-facies lobes- channels develop in South.
- Comparison: From DF13-1 to DF13-2 block, channel depths decrease and channels are deeply incised. Moreover, meander belts widen, and sinuosity increases (Fig 4).

## Discussion

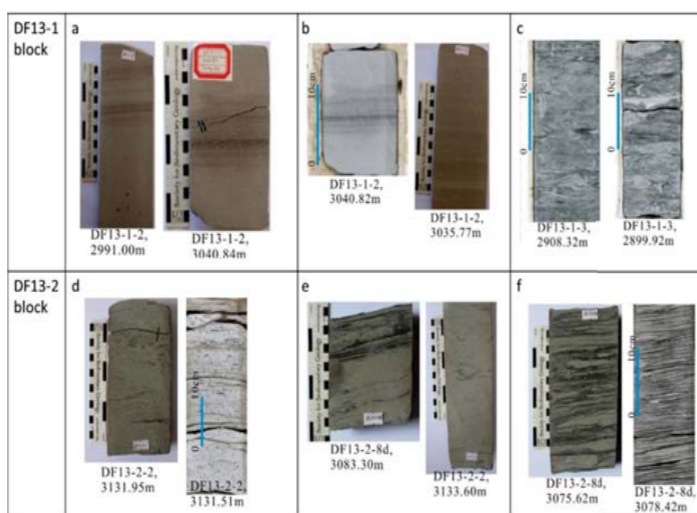


Fig.6. Comparison of sedimentary structures in DF13-1/2 blocks (first member of Huangliu Formation). (a) fine sandstone with deformation structures and parallel bedding; (b) fine sandstone containing striped mudstone with horizontal bedding, which reflects low hydrodynamic power and overbank facies; (c) siltstone with strong bioturbation supported by muddy matrix; (d) sandstone with conglomerates and gravels supported by coarse sandy matrix corresponding with highest hydrodynamic power and main channel facies; (e) fine sandstone with regional cross-bedding; (f) thin-bedded sandstone stratified sandy siltstone with current bedding, which reflects variation of hydrodynamic power.

- Abundant trace fossil Zoophycos has been found from DF1-1-12 in Huangliu Formation. The ratio of domichnia and fodinichnia from well DF1-1-12, DF13-1-2 and DF13-1-3 reflect the change of hydrodynamic power and overall volatile sedimentary environment (Fig 6). Sudden change in meander-belt size and channel sinuosity of these two blocks is clearly associated with the channel response to the relative sea level change.
- Result of reconstructing paleogeomorphology show that DF13-1 block has high gradient, which mainly distributes depositional lobes. However, DF13-2 block establishes low gradient, which mostly indicates braided channels (Fig 7).

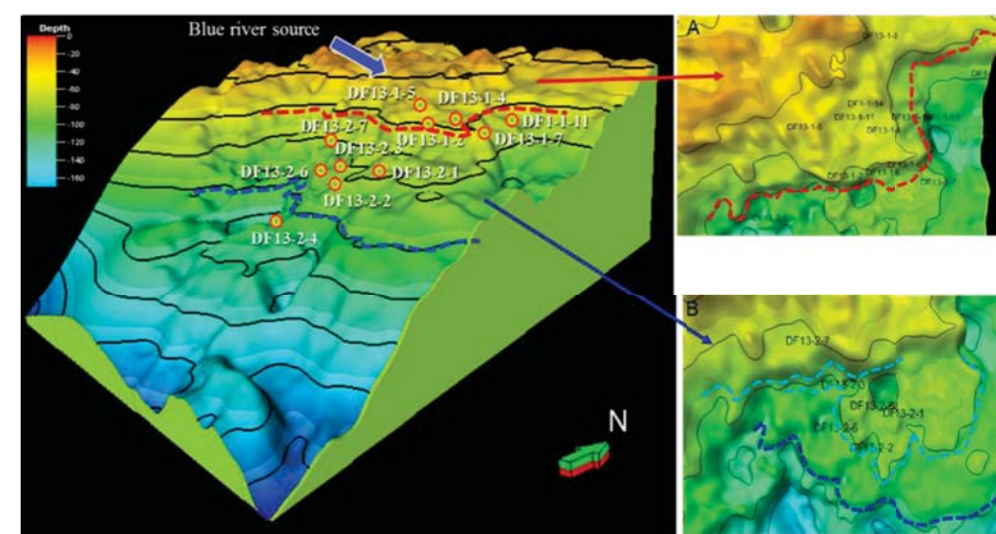


Fig.7. Comparison of paleogeomorphology of Huangliu formation in DF13-1 and DF13-2 blocks. A is the regional paleo-geomorphological configuration of DF13-1 block (Red dash line is the boundary between DF13-1 and DF13-2), B is the terraced regional paleo-geomorphological configuration of DF13-2 block (Blue dash lines are the boundaries).

## Conclusion

- DF13-1 block has gentle slope, which mainly distributes depositional lobes and relatively low sand-ground ratio.
- DF13-2 block establishes steep slope, which mostly indicates braided channels and high sand-ground ratio.
- DF13-2 block illustrates as lobed-channel and sand rich system, compared with DF13-1 of channelized-lobes and mud-sand rich system (Fig 8). Predictive models of channel-system morphology of these two blocks that might be applicable to the interpretation of thin bed reservoirs in similar settings in China.

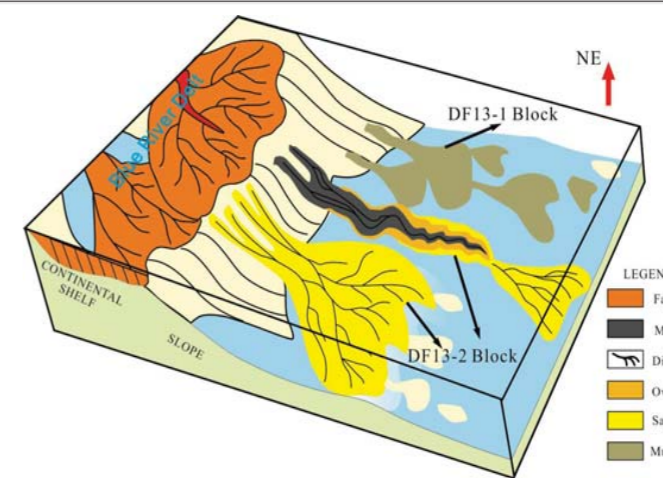


Fig.8. Depositional model of Ehl1 lobed channel system on the gentle slope in Dongfang areas.

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- Dorrik, A. V. S., Mayall, M., 2000. Deep-Water Sedimentary Systems: New Models for the 21st Century. Marine and Petroleum Geology, 17(2): 125–135.
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