

# Deep Water Oil and Gas Discovery of Pearl River Mouth Basin Guided by Geological and Geophysical Integrated Techniques

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Company CNOOC



## What's Next?

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**Schlumberger**

# Outline

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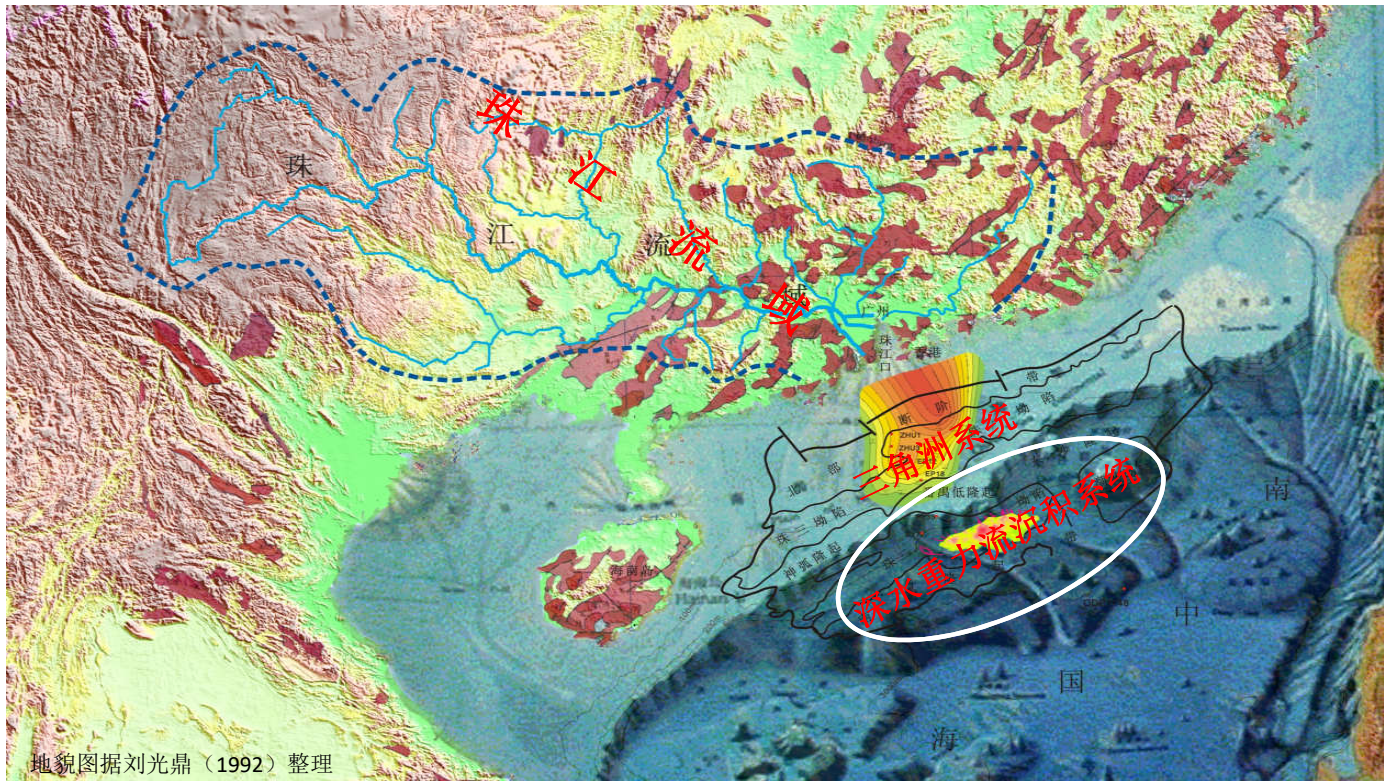
**Regional Geology and Problems**

**Key Techniques and Application**

**Summary and Suggestion**

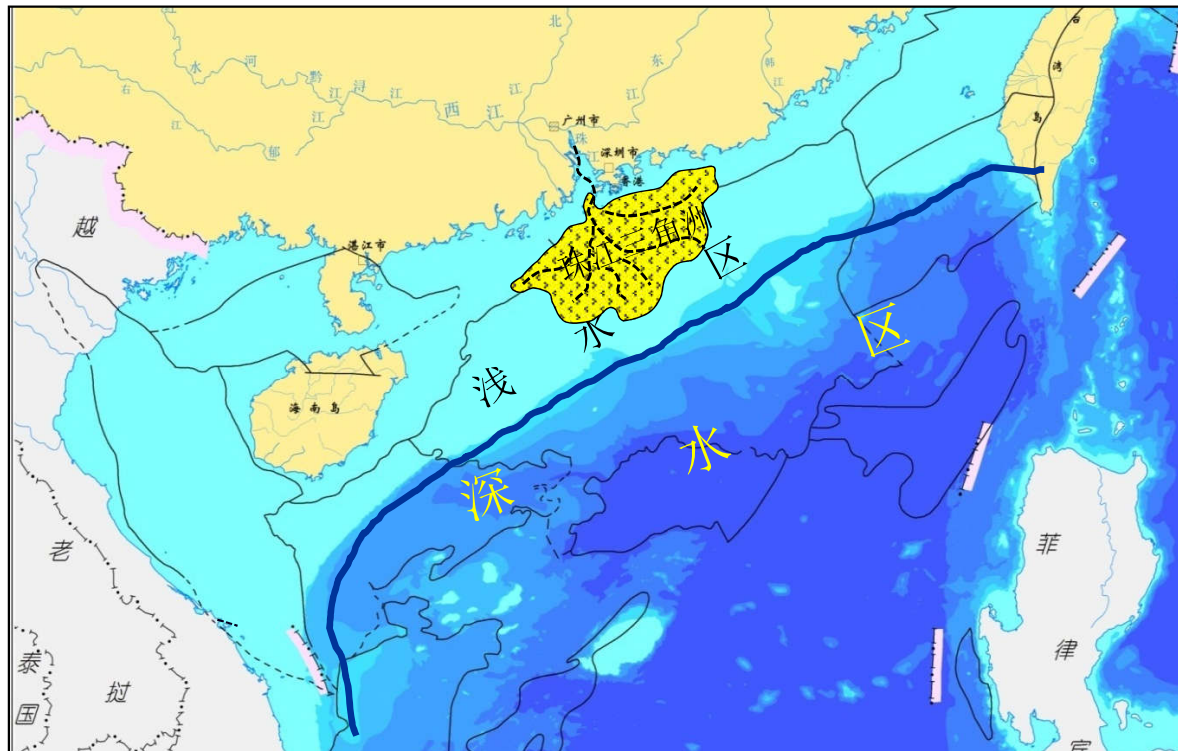
# Geological Setting of Baiyun Deepwater Area

Baiyun Deepwater Area is located at the **continental slope front of northern South China Sea**, and at the distal end of a sand rich river. It's one of the most important hydrocarbon exploration zone in offshore China.



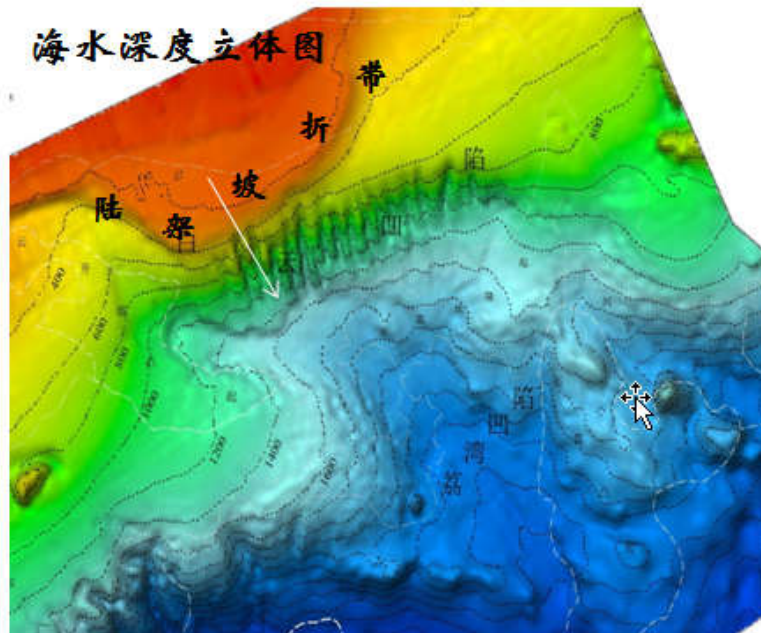
# Difficulties and Challenges

1. Due to the small size, lack of quality source rock and reservoir, oil companies such as BP and CHEVRON consider the exploration is risky in deep-water basin of northern South China Sea. Forming mechanism of large and medium sized oil and gas fields is a difficult problem that has to be overcome.

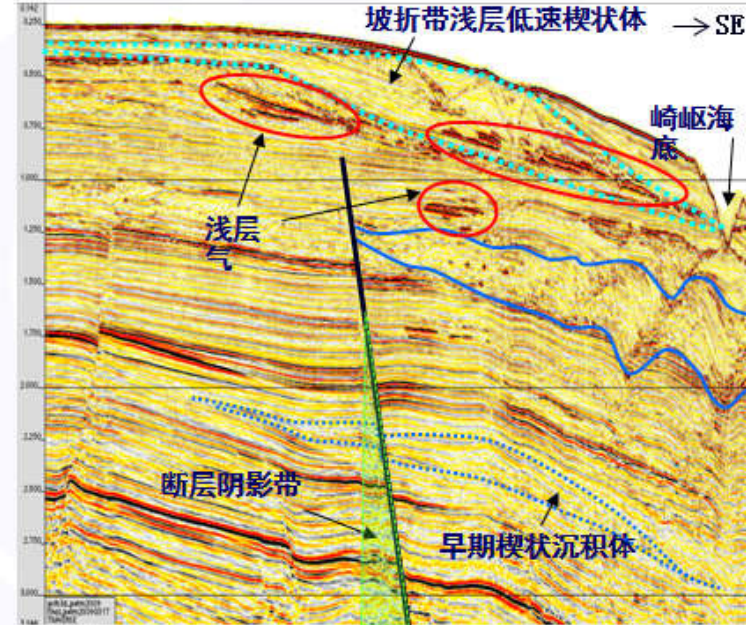


# Difficulties and Challenges

2. With steep slope, large water depth and rough seafloor, the shape and size of structural traps are difficult to describe.



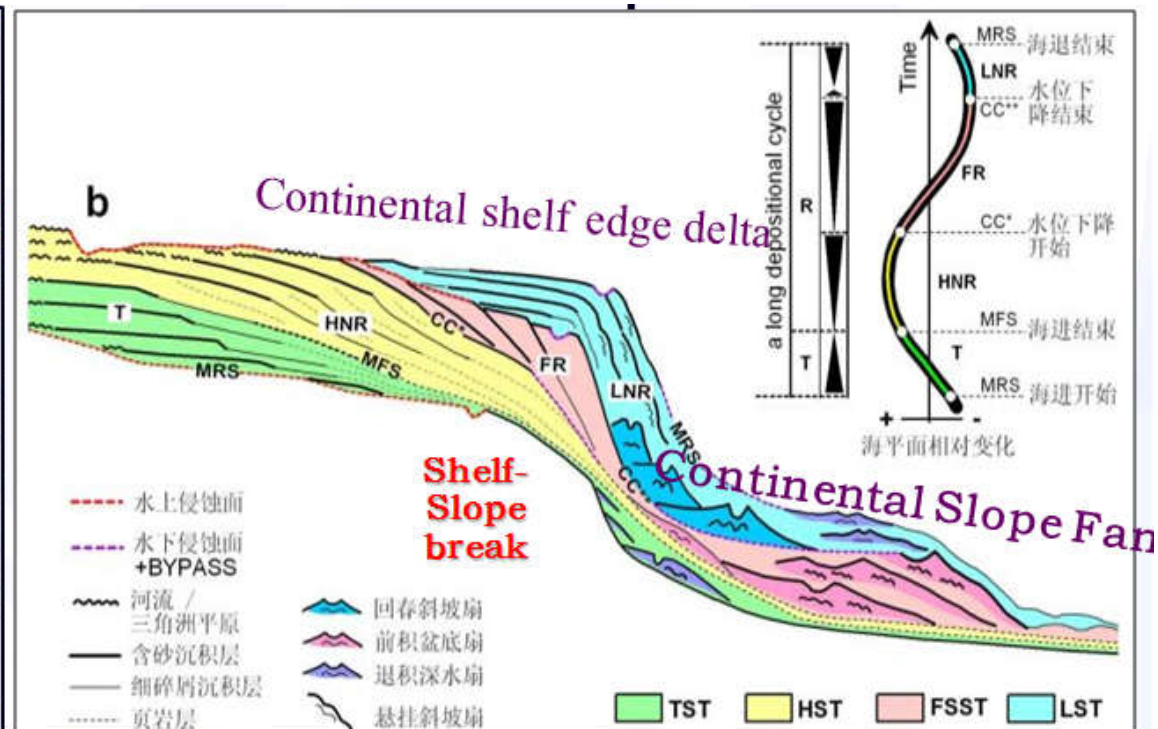
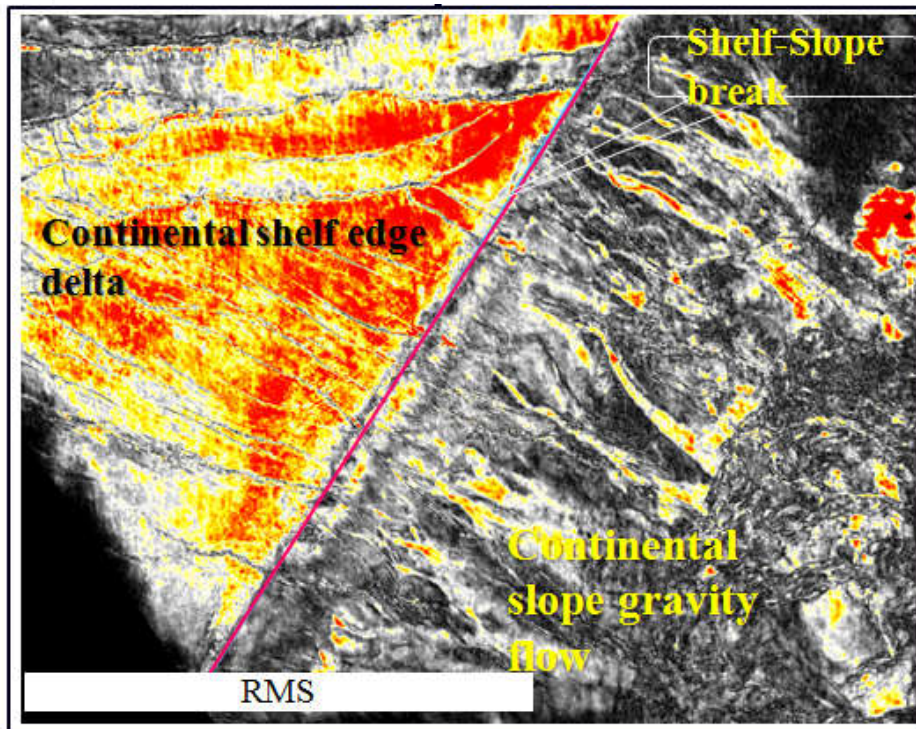
steep slope, large water depth  
and rough seafloor



Gas cloud, shallow geological features, fault shade  
affecting imaging quality of seismic data

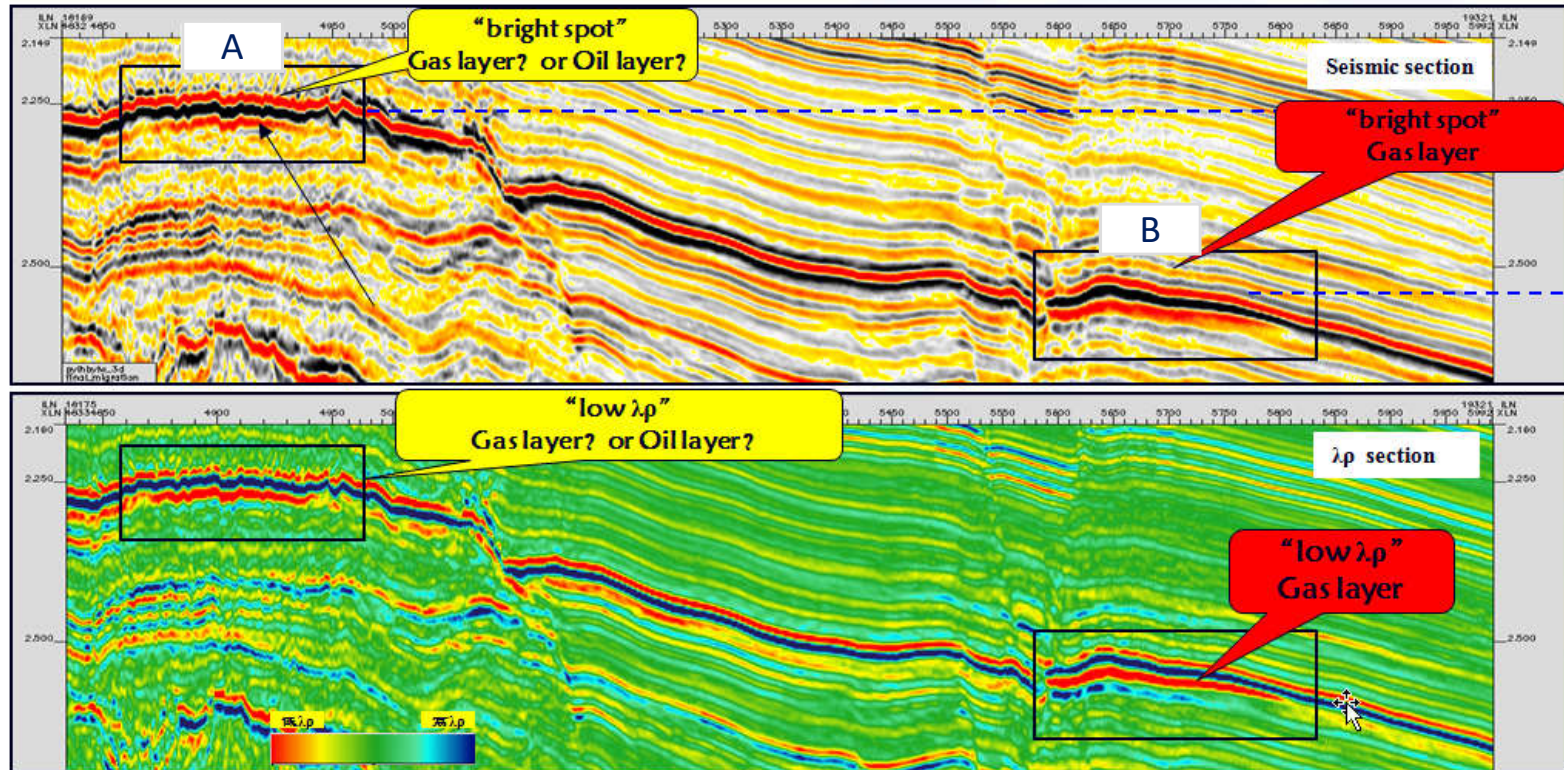
# Difficulties and Challenges

3. Deepwater gravity flow reservoir are complicated. How to improve the identification technique?

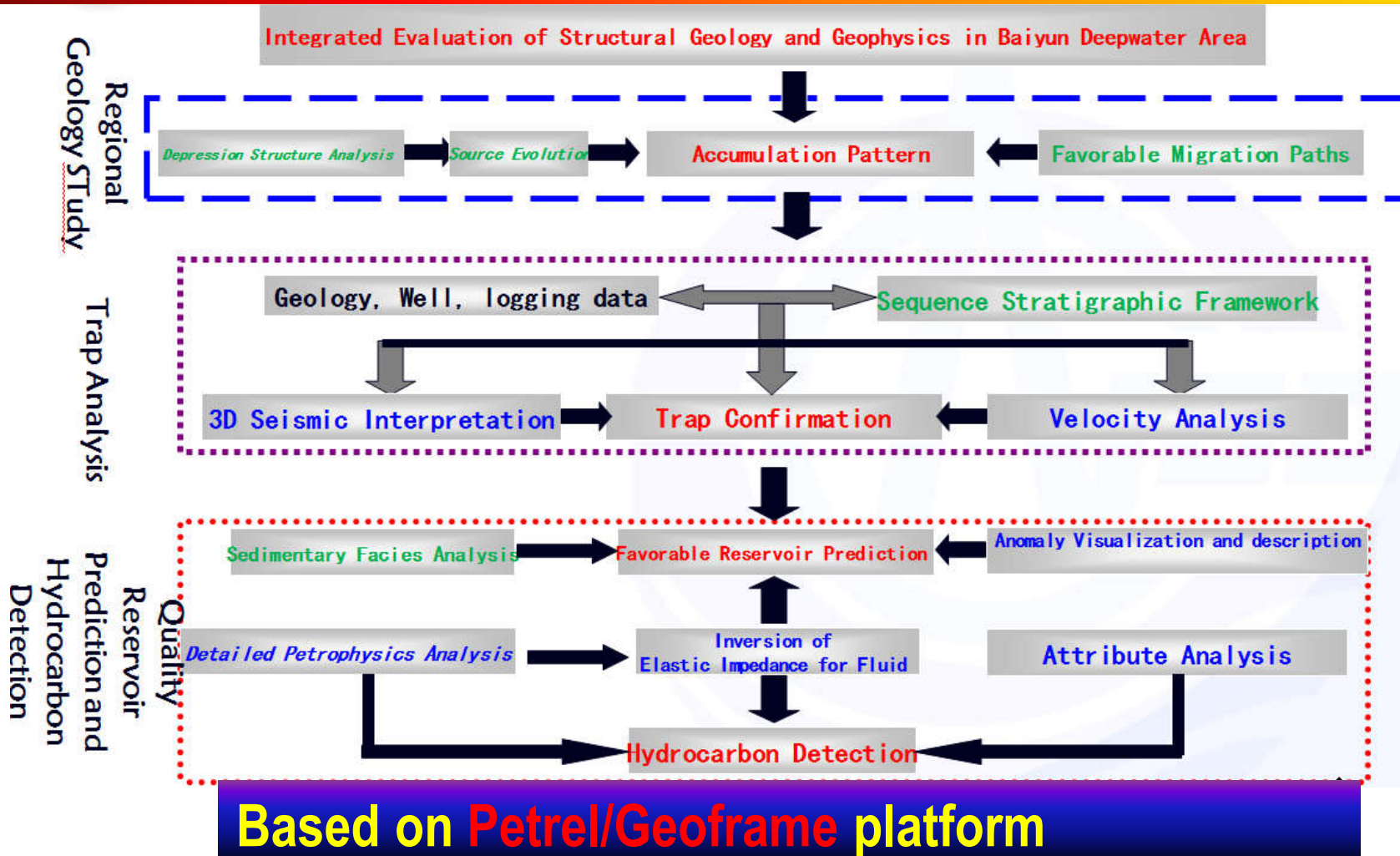


# Difficulties and Challenges

4. Hydrocarbon detection in “Atypical Bright Spot” is difficult, traditional methods are inefficient to discriminate oil, gas and water.



# Research and Technical Approach





# Outline

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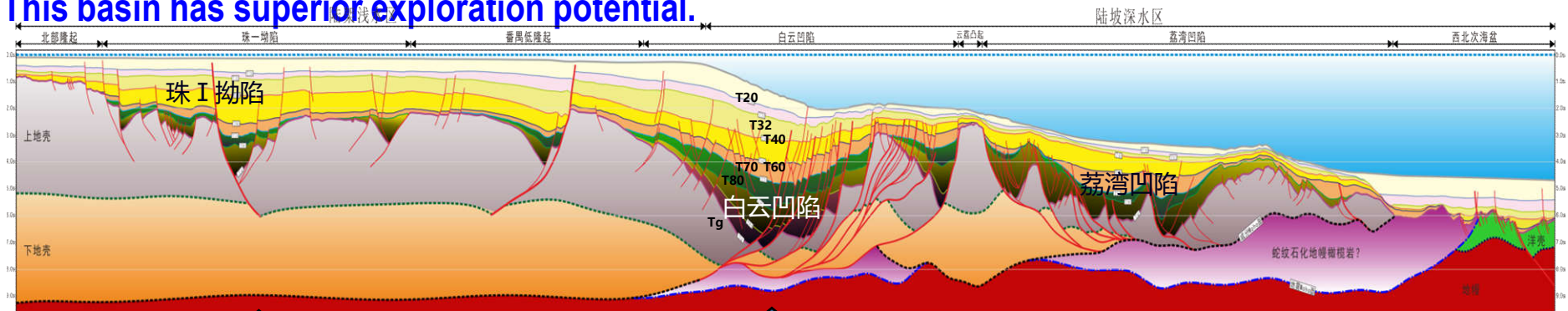
**Regional Geology and Problems**

**Key Techniques and Application**

**Summary and Suggestion**

# Key Application Technique 1: Petroleum Accumulation Analysis

1. Baiyun Depression has massive oil and gas generation potential and the source kerogen is mainly type II. This basin has superior exploration potential.



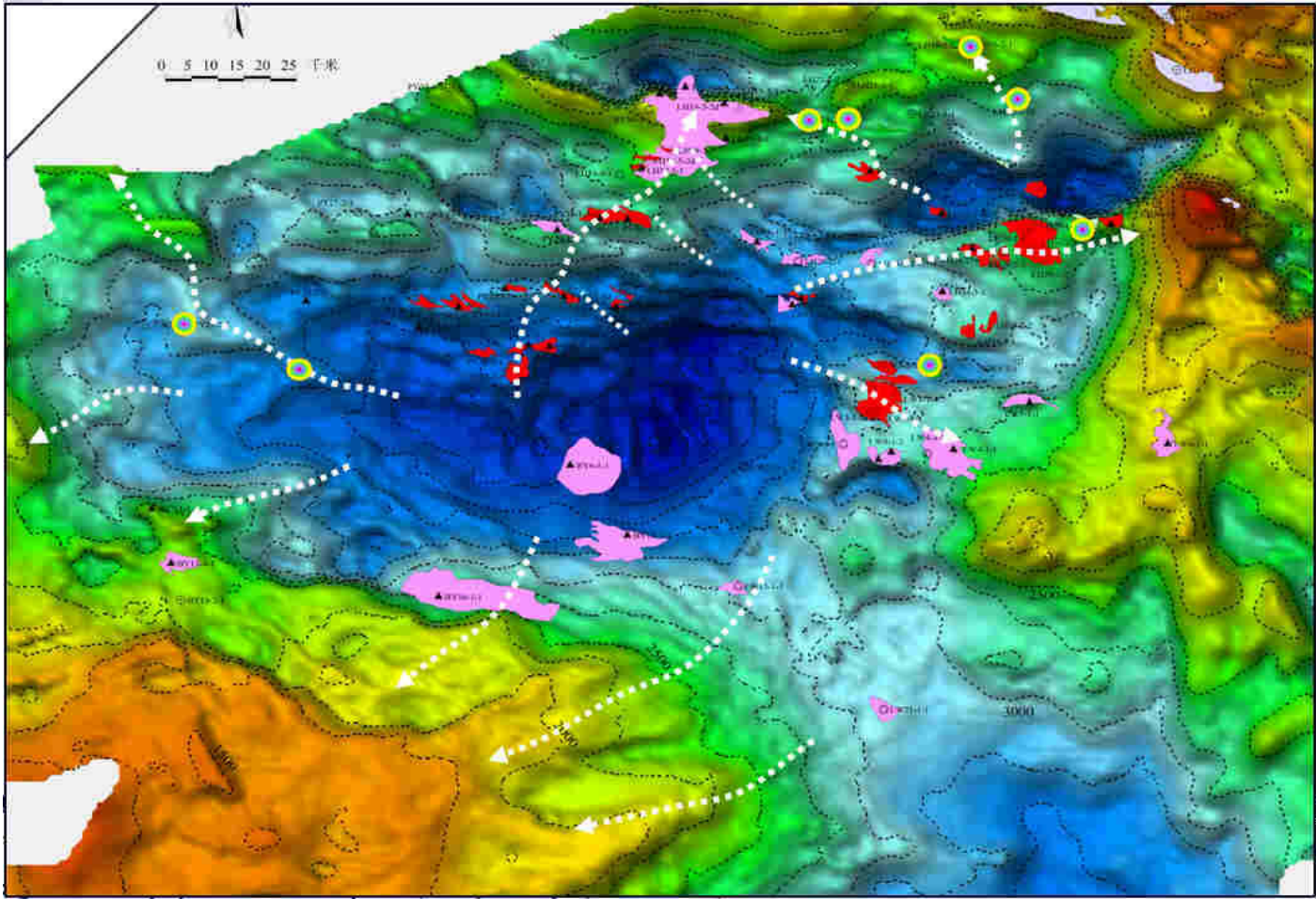
↑  
Elongated half-graben controlled by high angle faults in upper crust

↑  
Broad faulted basin controlled by detachment faults in intensive extension zone

(1) Baiyun Depression is a “broad-deep” faulted basin on the continental crust thinning zone. The depression area is 22341km<sup>2</sup>, with 13000m Cenozoic strata and 7000m Paleogene strata. It’s a larger basin than Zhu I Depression.

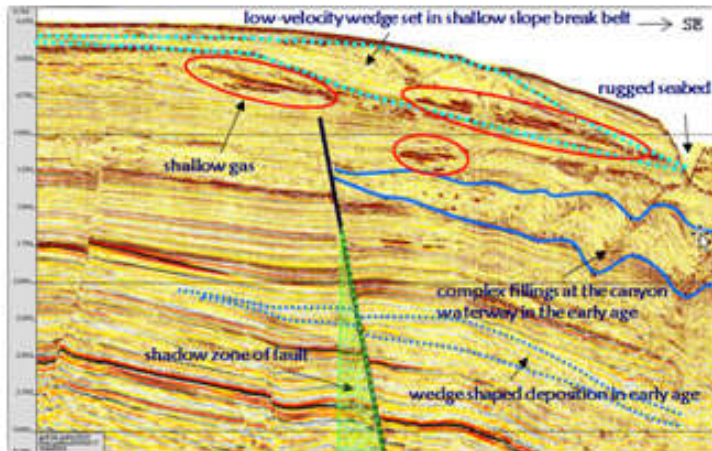
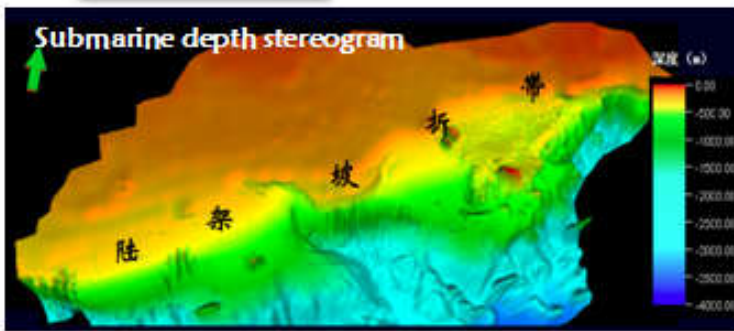
(2) Large scale of deltaic-lacustrine deposition in the basin, the maximum thickness of lacustrine deposit is over 4700m and the area is 6900km<sup>2</sup>. The source rock size is massive.

# Comprehensive Evaluation 'Source - Collection - Accumulation' of Baiyun Sag



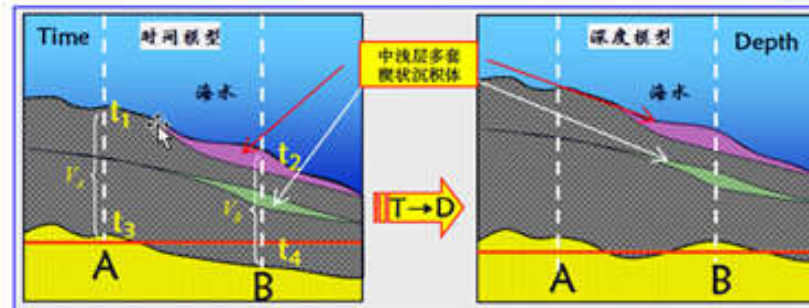
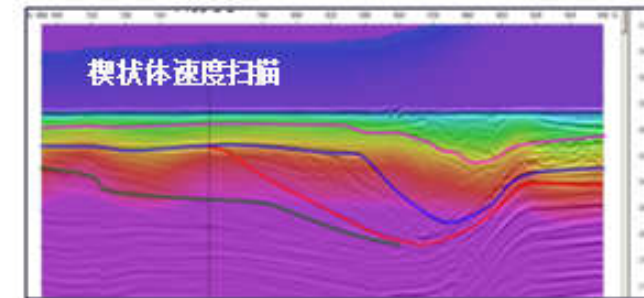
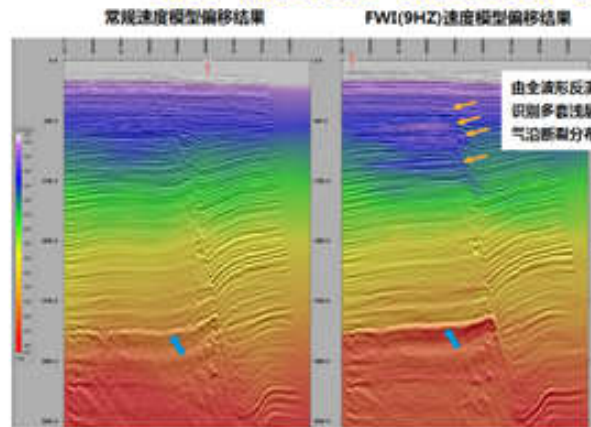
# Key technology 2: High-accuracy velocity analysis & structural correction in deep water zone

## Difficulty

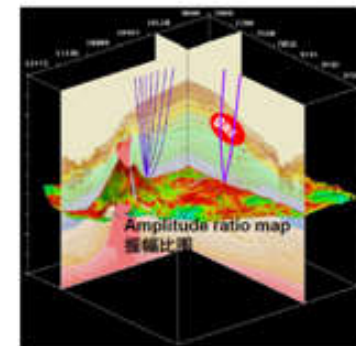


## Innovative Technology

- Full waveform inversion velocity model (FWI) + QPSDM

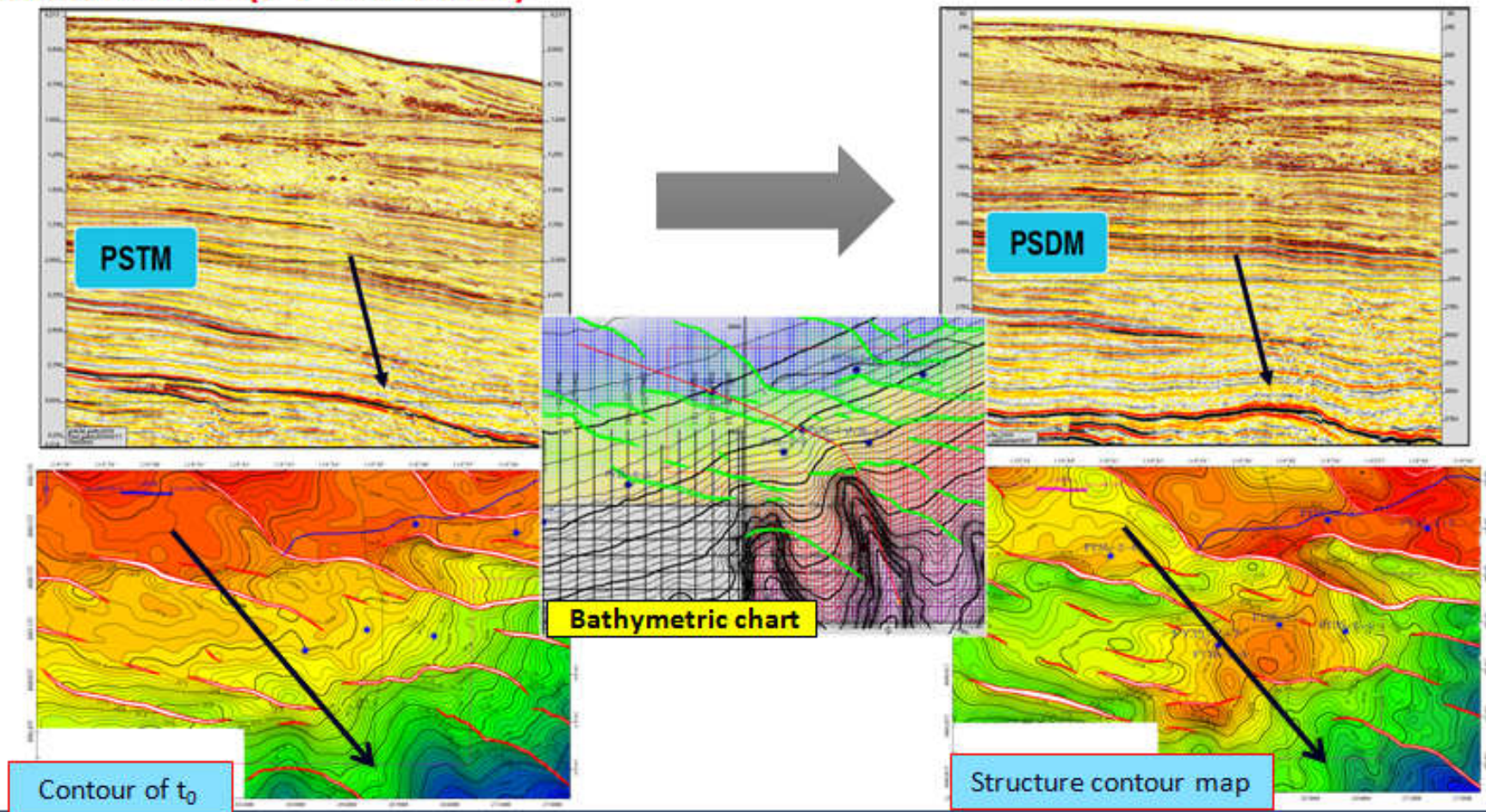


sketch map of structural correction technology for high - variable velocity region in deep water zone



# Key technology 2: High-accuracy velocity analysis & structural correction in deep water zone

## Application results (P1 Gas Field)

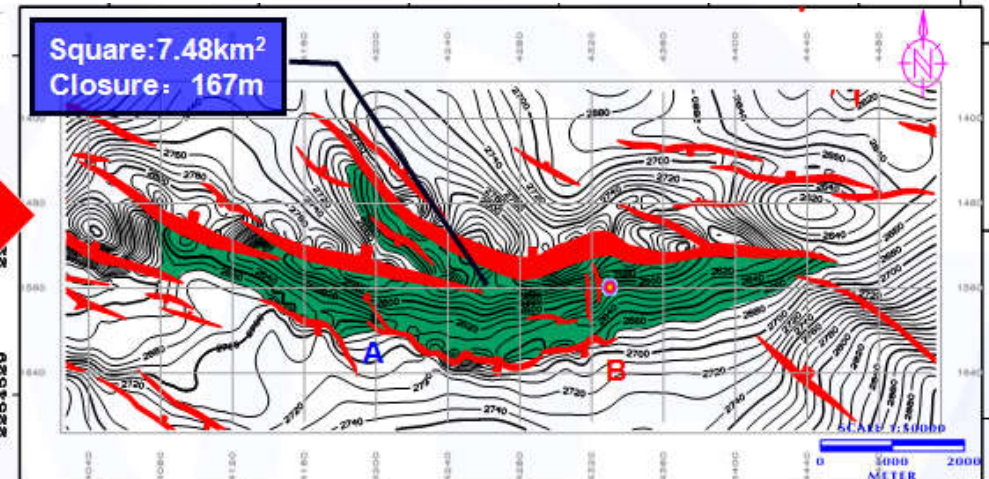
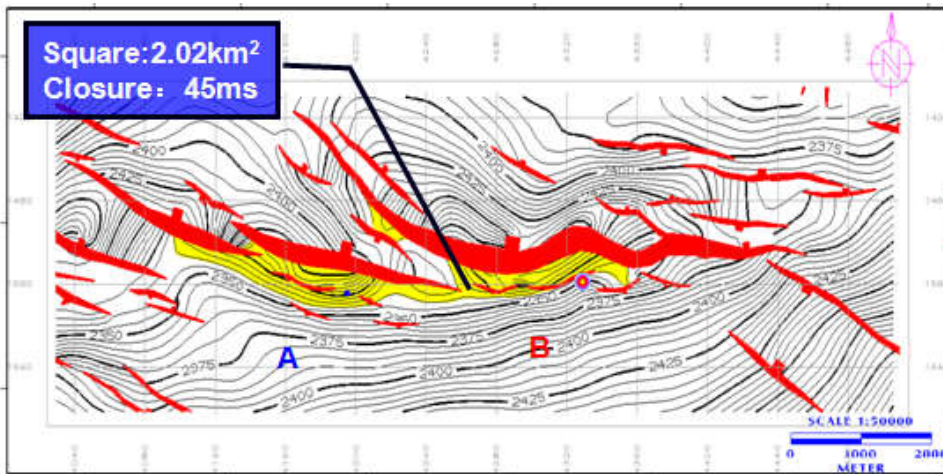


# Key technology 2: High-accuracy velocity analysis & structural correction in deep water zone

## Application results (L1 Oil Field)

Contour of  $t_0$  in layer T50

structure contour map of layer T50



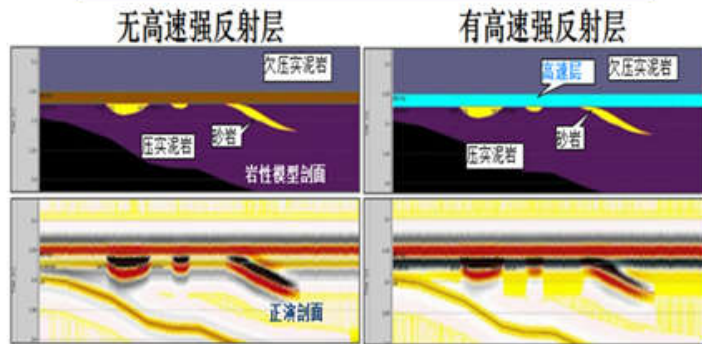
Area of time-trap is only 2.02km<sup>2</sup>, depth: 7.48km<sup>2</sup>, increased by 3.7 times !

Relative error of actual drilling depth is smaller than 3%

# Key technology 3: Fine reservoir description of gravity - flow reservoir in deep water zone

## Reservoir prediction at the reservoir with strong reflectivity

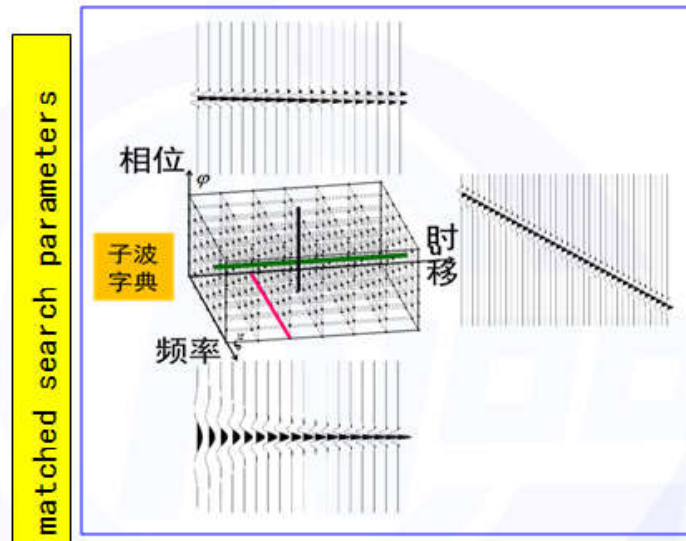
Mudstone dehydration + Transgressive gray matter deposition, high uncertainty in detection of lithologic trap boundary and fluid identification due to the high-velocity layer in the sand body



- Adaptive decomposition of signals are achieved using matching pursuit algorithm. The seismic signals can be expressed by the linear combination of matched time - frequency atoms by decomposing the signals in over-complete atom library

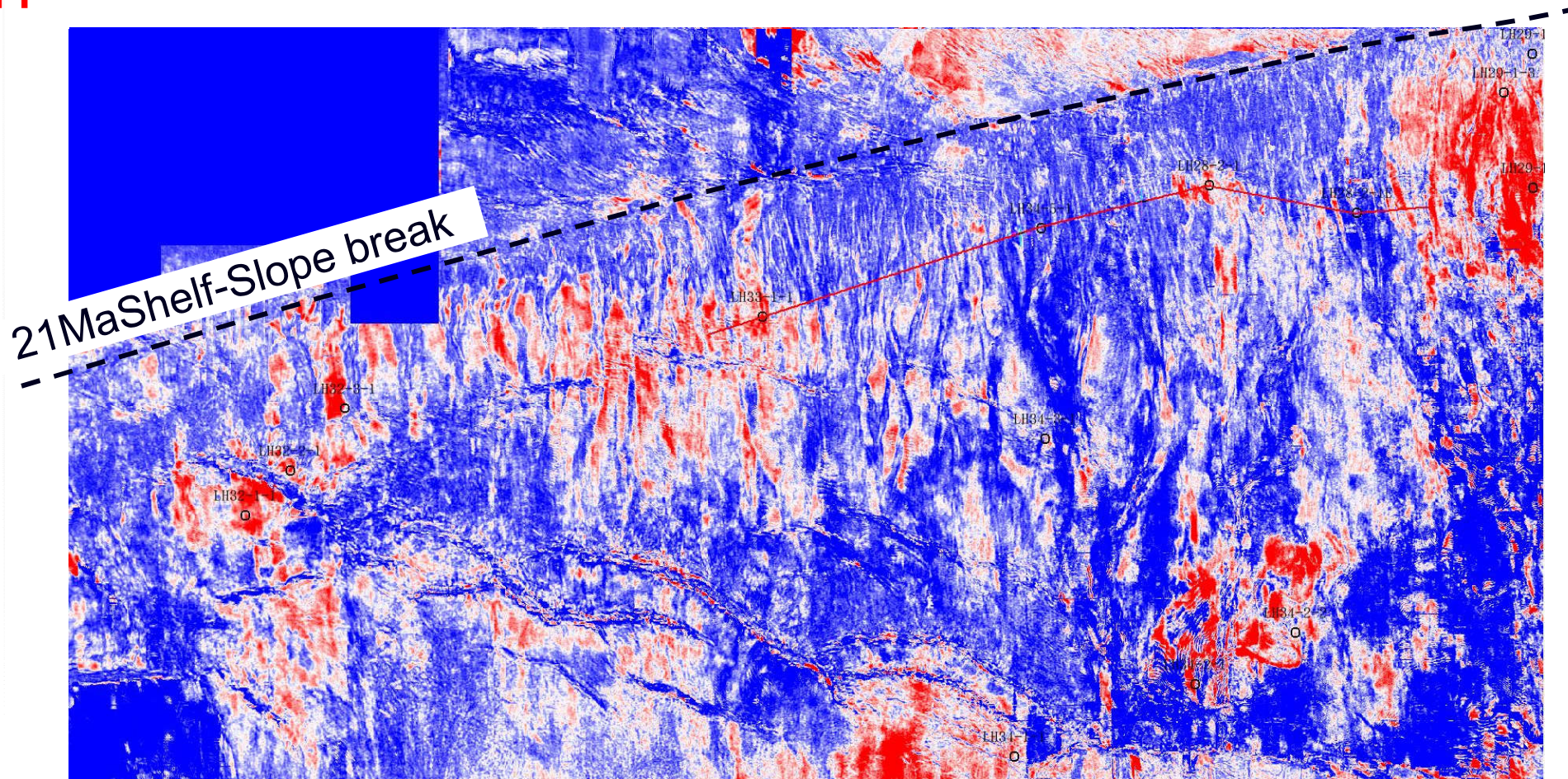
$$\hat{\alpha} = \arg \min_{\alpha} \frac{1}{2} \| D\alpha - y \|_2^2 \quad s.t. \quad \|\alpha\|_0 \leq \delta \quad \longrightarrow \quad \hat{x} = D\hat{\alpha}$$

Time - frequency atoms suited to the high - velocity layer with strong reflectivity obtained by using matching pursuit algorithm searched from wavelet dictionary



# Key technology 3: Fine reservoir description of gravity - flow reservoir in deep water zone

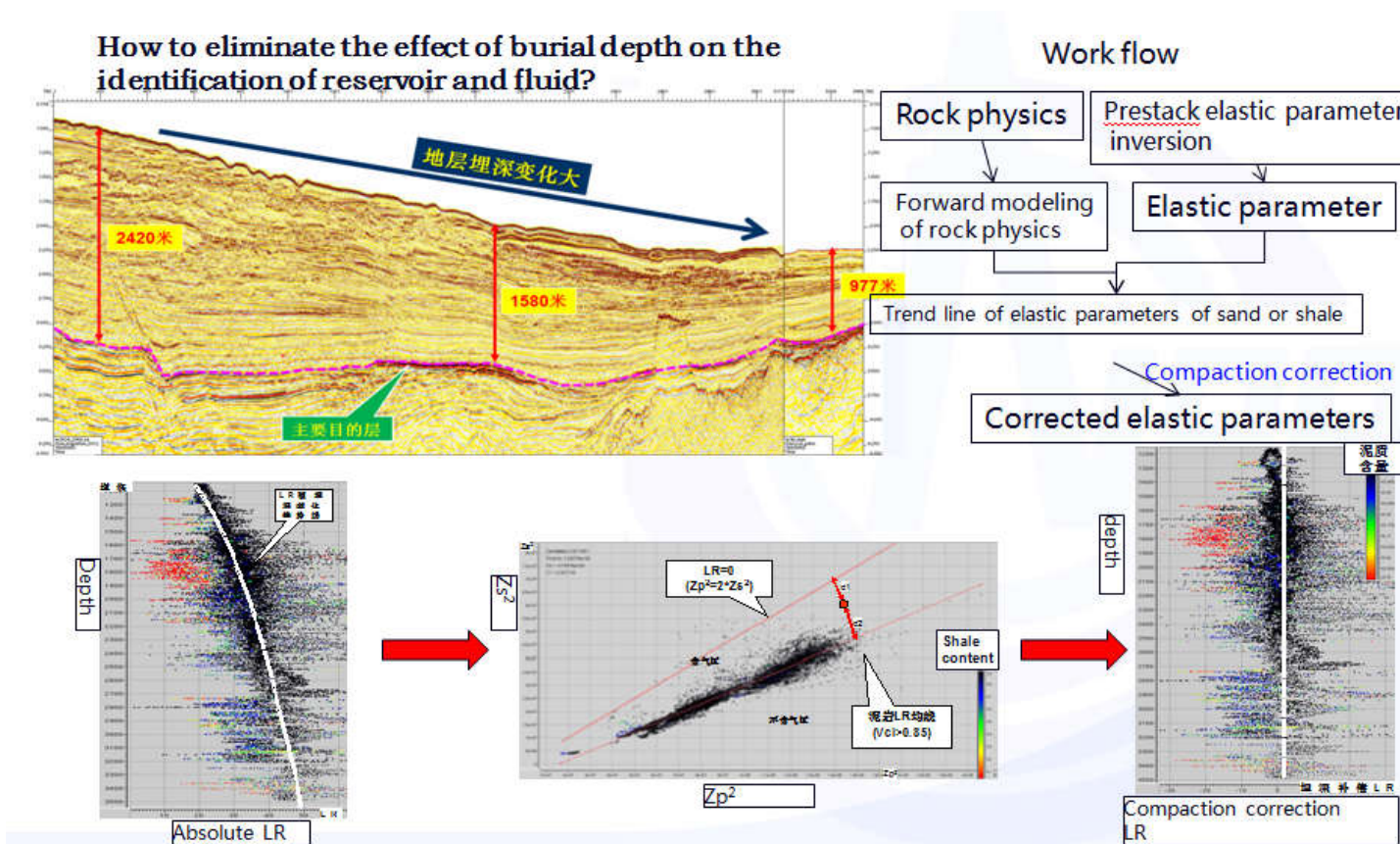
## Application Results





# Key technology 3: Fine reservoir description of gravity - flow reservoir in deep water zone

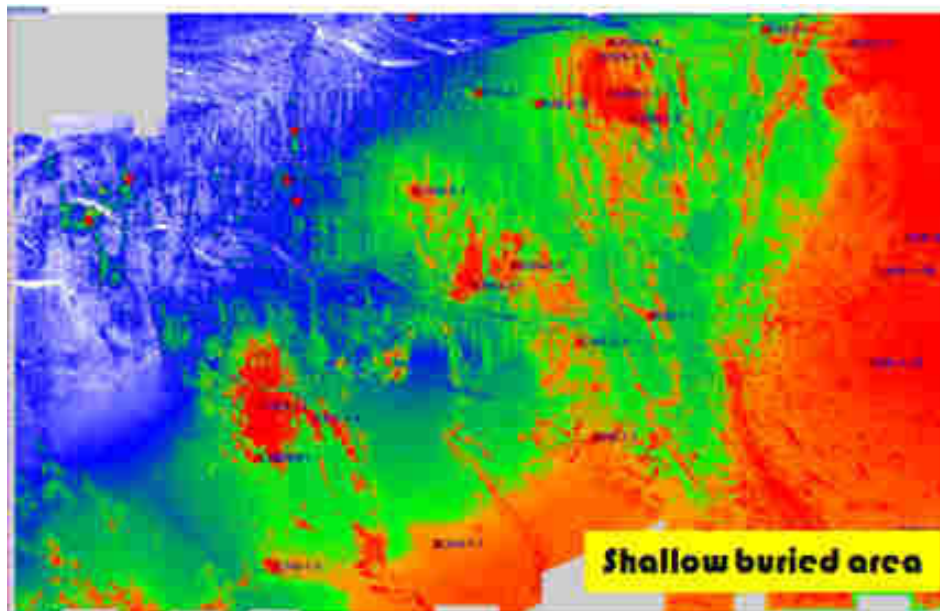
## Compaction correction of elastic parameters



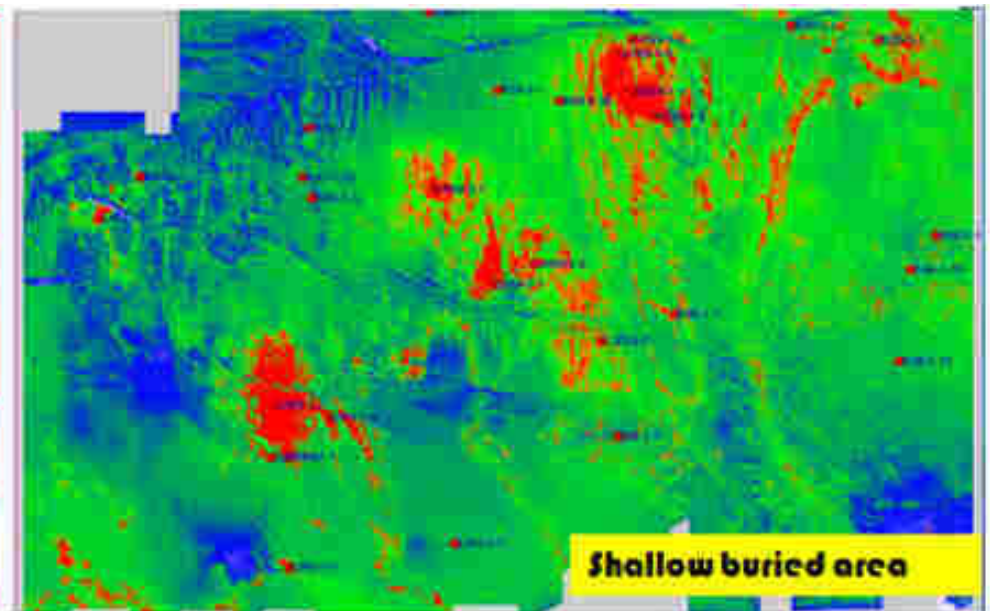
# Key technology 3: Fine reservoir description of gravity - flow reservoir in deep water zone

## Application Results

LR attribute distribution **before** compaction correction of buried depth

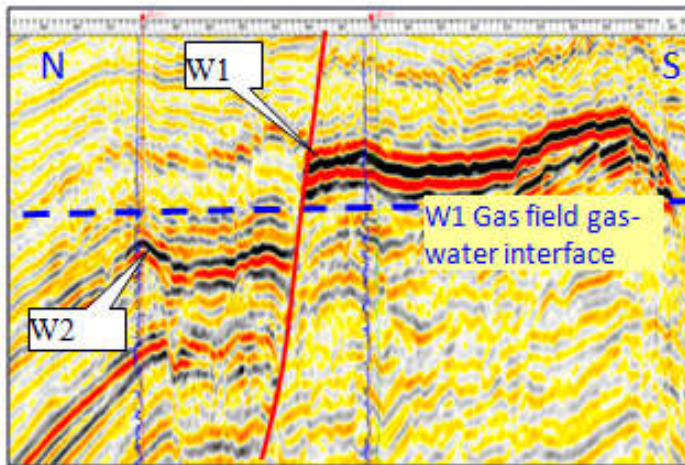


LR attribute distribution **after** compaction correction of buried depth



# Key technology 4: Comprehensive prediction technique of hydrocarbon reservoir with “Atypical Bright Spot” in deep water zone

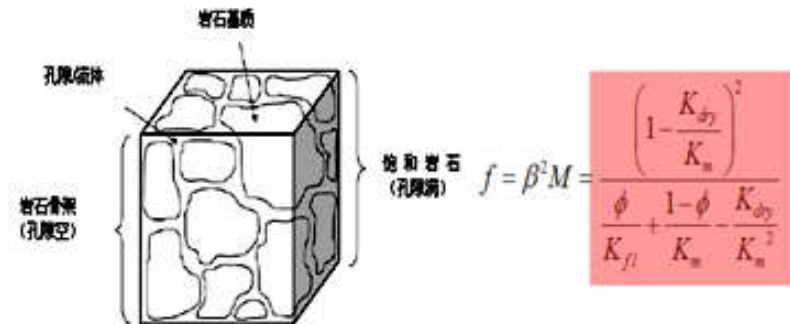
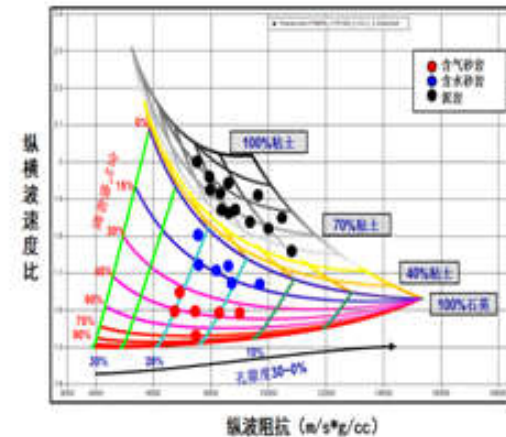
## “Atypical Bright Spot” hydrocarbon reservoir



Influenced by factors such as compaction, reservoir properties and special lithology, hydrocarbon reservoir with “Atypical Bright Spot” refers to subtle reservoir with unobvious bright spot feature on seismic section. It is hard to be identified by conventional hydrocarbon detection methods.

## Innovative Technology

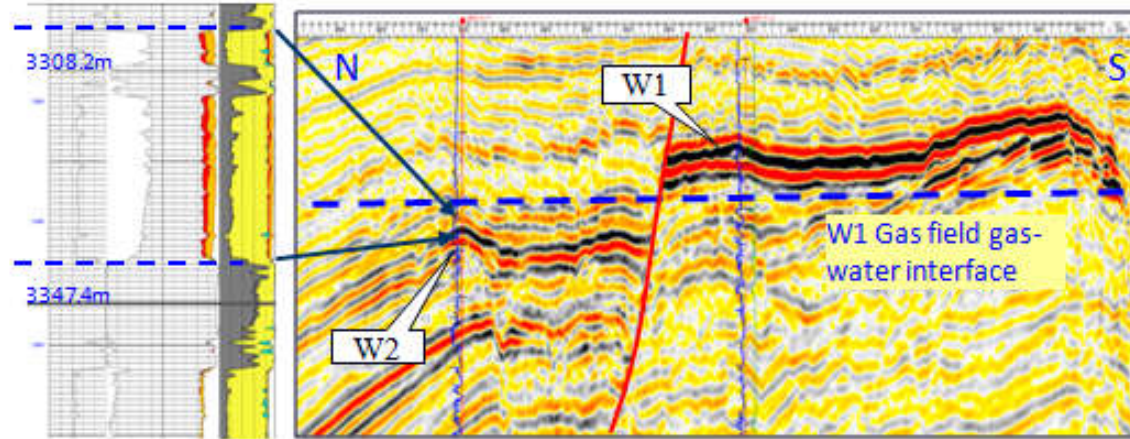
- Lithofacies fluid rock physics template



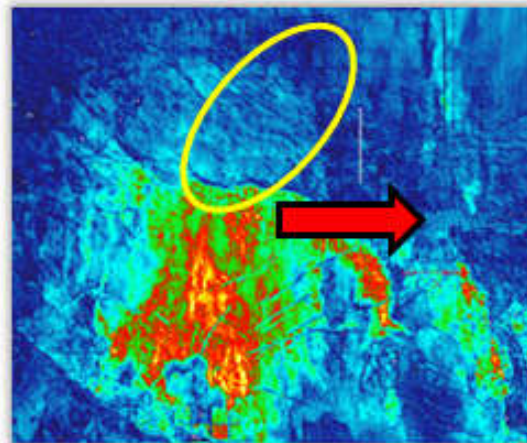
- Optimized fluid factor direct inversion

# Key technology 4: Comprehensive “Atypical Bright Spot” hydrocarbon reservoir prediction in deep water zone

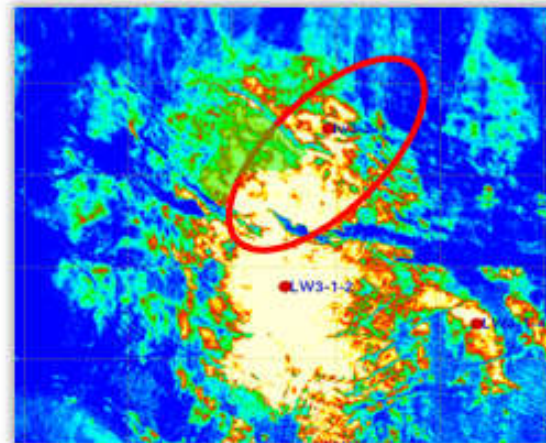
## Application Results (W2 Gas Field)



Prediction of single attribute (p wave impedance) shows no abnormal in target zone.

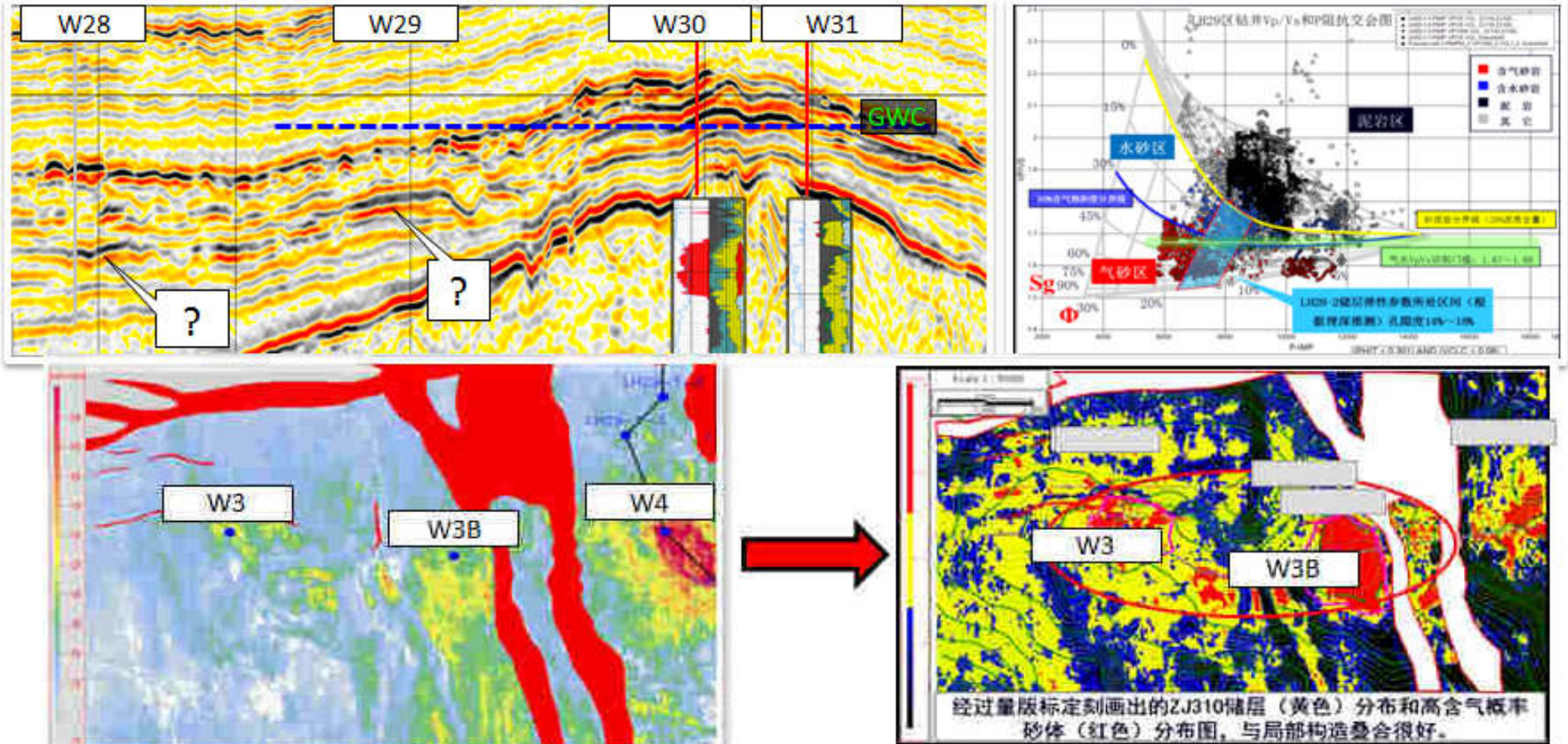


Rock physics template indicates target zone has the same gas-bearing probability as W1 gas field



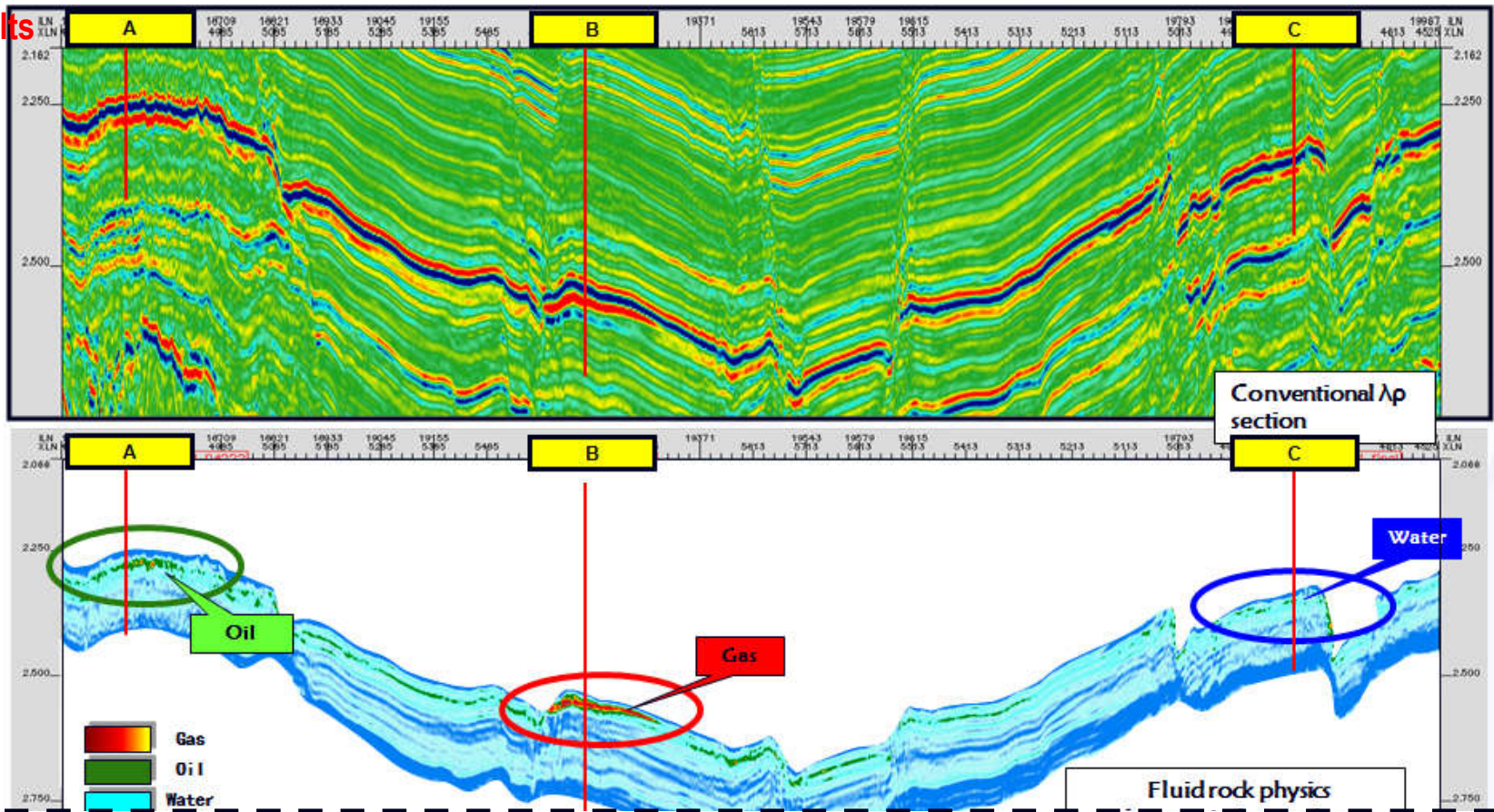
# Key technology 4: Comprehensive “Atypical Bright Spot” hydrocarbon reservoir prediction in deep water zone

## Application Results (W3 Gas Field)



# Key Application Technique 1: Light oil identification technology

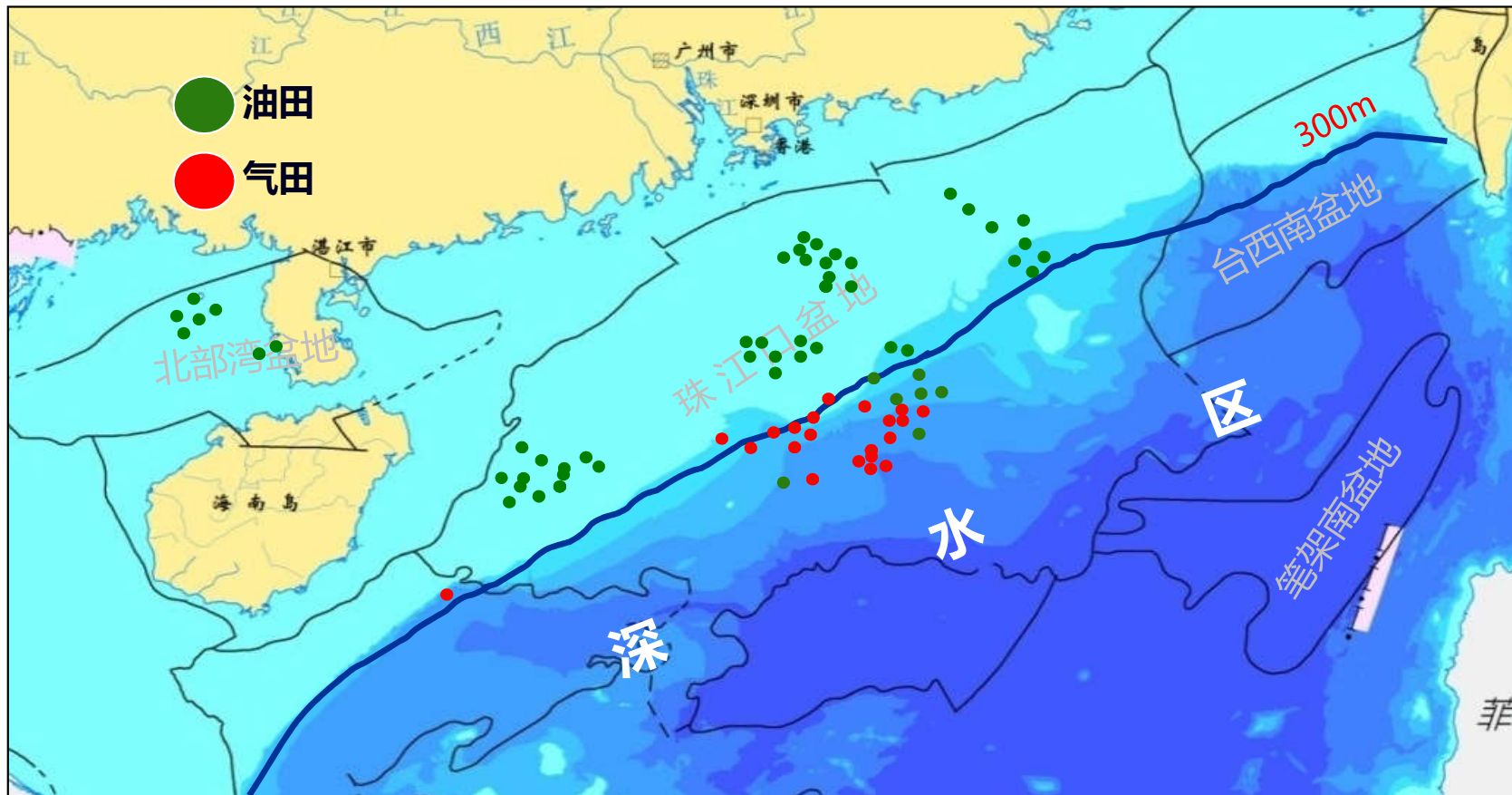
## Application Results



Utilizing the technique of fluid rock physics template and pre-stack fluid factor direct inversion, oil, gas and water are effectively distinguished.

# Results

The research reveals the differential thermal evolution of the source rocks in the Baiyun depression controlled by geothermal gradient. Until now, the third grade crude oil geological reserves in Baiyun depression is over  $100 \times 10^6 \text{ m}^3$  and the tertiary natural gas reserves has exceed  $50 \times 10^9 \text{ m}^3$ . The discovery of multiple oil and gas fields reveals the exploration potential of Baiyun depression.



# Outline

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**Regional Geology and Problems**

**Key Techniques and Application**

**Summary and Suggestion**



# Summary and Suggestion

1

As a basic platform for exploration research, Geoframe can reveal both geological and seismic information, it also can reduce the exploration risk by fully utilizing comprehensive approaches, such as seismic slices, seismic reflection characteristics, seismic attributes, seismic phase analysis, etc.

2

Quantitative prediction of limestone and sandstone by 3D visualization technique, has played an important role trap evaluatin and rolling exploration.

3

Geoviz 3D visualization interpretation platform has solved the issue of large-scale 3D seismic interpretation. It allow us be able to observe the structural features and contact relationship of strata underground. which can save our time and increase work efficiency.

Suggestion

Establish an online consulting platform.

# Conclusions

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- Although oil price remains in the doldrums, our exploration needs to remain optimistic. This self-confidence coming from the depression resource evaluation, and exploration success depends on the comprehensively understanding the depression accumulation system and effective application of geophysical technology.

**Thanks**



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