

# **The Discovery and Exploration Potential of the Eocene-Miocene Shelf Margin Deltas in the Baiyun Sag of Pearl River Mouth Basin, South China Sea\***

**Qiang Xu<sup>1</sup>, Weilin Zhu<sup>2</sup>, Yingmin Wang<sup>3</sup>, Ming Lv<sup>1</sup>, Kai Zhong<sup>2</sup>, Dong Li<sup>3</sup> and Dan Wang<sup>1</sup>**

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<sup>1</sup>CNOOC Research Center, Beijing, 100027, Beijing, China. ([wang-dan@139.com](mailto:wang-dan@139.com))

<sup>2</sup>CNOOC Limited, China, Beijing, 100010, Beijing, China.

<sup>3</sup>China University of Petroleum (Beijing), Beijing, 102249, Beijing, China.

## **Abstract**

The Baiyun Sag is a subunit of the Pearl River Mouth Basin and is situated in the deepwater region of the north slope of the South China Sea. Through analyzing faults and sedimentary structures and combining analysis with a study of magmatism, the Baiyun Sag is defined as a composite rift. The faulting and the sedimentary history of the Baiyun Sag are also influenced by spreading in the South China Sea Basin. The exploration potential of the subunit is demonstrated by the recent discovery of the LW3-1 gas field and other gas discoveries along the north slope of the sag. To bring exploration in the sag one step further, a better understanding of the depositional environments and characteristics of the Oligocene-Miocene Shelf Margin Deltas successions is critical.

Retreating shelf break occurred from Oligocene to Miocene in deep water area of Baiyun depression South China Sea, which controlled the development and distribution of sediment in the area, and to some extent effected reserves form and distribution. Base on the latest drilling data, detail sedimentary analysis and meticulous interpretation of long cable, high quality, three dimensional seismic data, research of sedimentary response of retreating shelf break is carried out, meanwhile integrating the theories of shelf-margin delta, which indicated that the response of shelf break moving is shelf-margin delta progradational system of Zhuhai Formation in Oligocene and growth faults complicating shelf-margin delta and deep-water fan system of Zhujiang Formation. This discovery will benefit oil and gas exploration of Baiyun Depression.

Through integrated analysis of well log, core, and high-resolution 3D seismic data, a series of Oligocene-Miocene shelf margin deltas were discovered recently in the sag. During the Oligocene, these deltas prograded primarily under late lowstand conditions and delta-front deposits were well developed. On north-south, high-resolution seismic profiles of the Baiyun sag, classic delta progradational

reflection is very clear under 23.8Ma reflecting interface, in which the gap between up surface and bottom surface reaches 100-400m and extends horizontally up to several kilometers. All these prove that the deltas progradation are formed in the shelf break. And the large classic delta progradational reflection with wedges in both sides, which is also the distinct character of shelf margin delta, can be found on north-south, high-resolution seismic profiles. From the core analysis of Zhuhai Formation in LW3-1-1, there is a transmutation from deep-sea sediments to gravity flow deposits, finally to shallow shelf deposition, which reveals the process that continental shelf margin delta prograded from continental shelf to slope and prompted slope-break zones moving to deep sea. Shelf break during this time was controlled to a significant extent by normal faulting, which is one of the most important pathways for hydrocarbon migration. And the system grew towards the upper slope with distinct “S” geometries. During the Miocene, in contrast, the depositional mechanism changed and there were more gravity-flow processes in the extended space between the outer shelf and the upper slope. This is because the Baiyun sag subsided causing the slope-break to migrate northward, creating a steeper slope. Accompanied by rising sea levels, the Baiyun Sag transformed into an upper slope deep water environment. Although classic delta progradational reflection in the Zhujiang Formation is not as common as that in the Zhuhai Formation, in the north slope shelf break of the Baiyun Sag, there is visible shelf margin delta progradational reflection. Typical depositional elements identified in the delta-front successions of the shelf margin deltas include distributary channels, mouth bars, tongue-shaped sediment-failure, sediment-gravity-flow deposits, and shelf-slope channels. Core analysis of LW 311 reveals that gravity-flow deposits in the Zhujiang Formation is different from the typical turbidite, because the probability diagrams of integration curves created by sandstone particle size analysis reflects tractive current character, not turbidity current and bioclastics in sandstone. Furthermore petrographic thin sections of the sandstone show that minerals are sorted well, clay content is low and the structure and composition of maturity are high. These features indicate that sediments on the upper slope are clastics that transported from shelf margin delta front to upper slope through outside shelf channel, incised valley and sag, while the development of intermittent gravity flow turbidity.

Siliclastic supply from the feeding rivers of the shelf margin deltas, coupled with the carbonate source from the nearby Dongsha Uplift, provides sufficient material not only for the growth of the shelf margin deltas but also for the development of their linked deepwater system. In the seismic profile west along Dongsha Uplift, classic delta progradational reflection can be seen clearly from east to west, and erosion phenomenon is very obvious in Zhujiang Formation on Dongsha Uplift. All these proofs indicate that Dongsha Uplift was once source areas of Baiyun Sag in Miocene.

The integrated data set and recent exploration results along the LH34 and the LH29 districts demonstrate the genetic link between the shelf margin deltas and the deepwater systems further basinward, indicating that there is huge exploration potential in the sag. But good reservoirs are always found along the shelf break direction, and in the vertical direction of the shelf break the sandstone are so poor and thin that they cannot be good reservoirs. This finding will provide new ideas for oil and gas exploration in the region.

# AAPG 2011 Annual Convention & Exhibition



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1. CNOOC Research Center, 100027, Beijing, China.
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3. China University of Petroleum (Beijing), 102249, Beijing, China.

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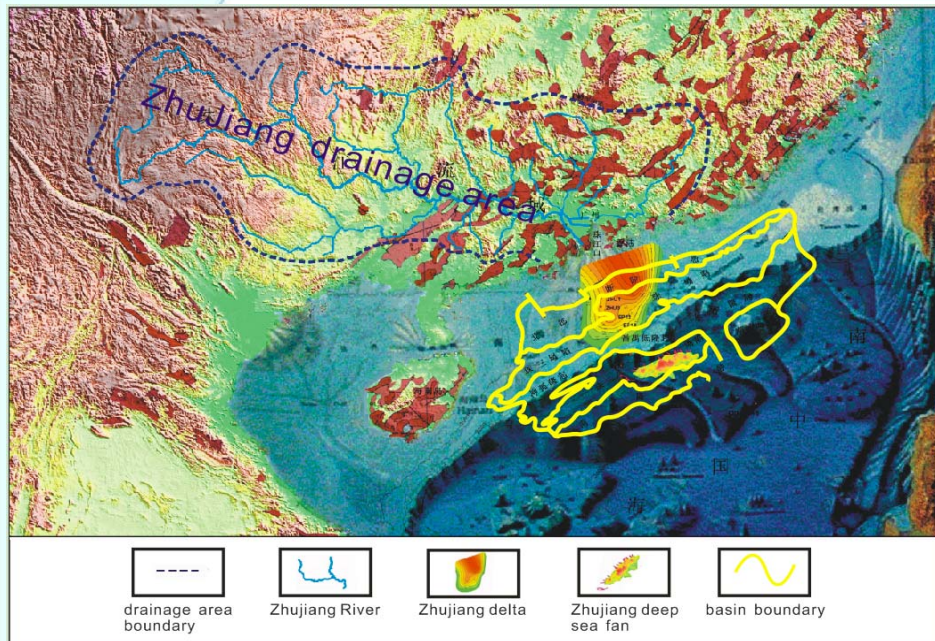
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- **5. Conclusion**





# 1.The Geology Of The Research Area

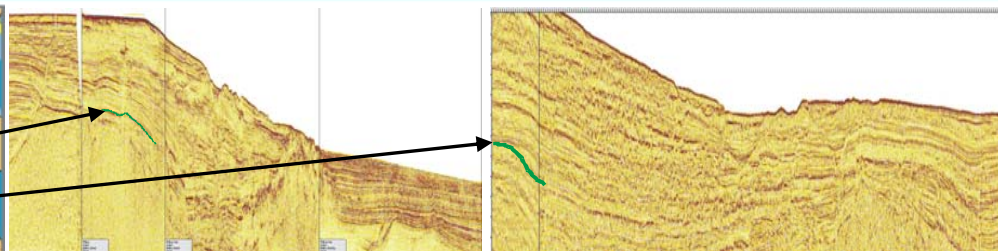
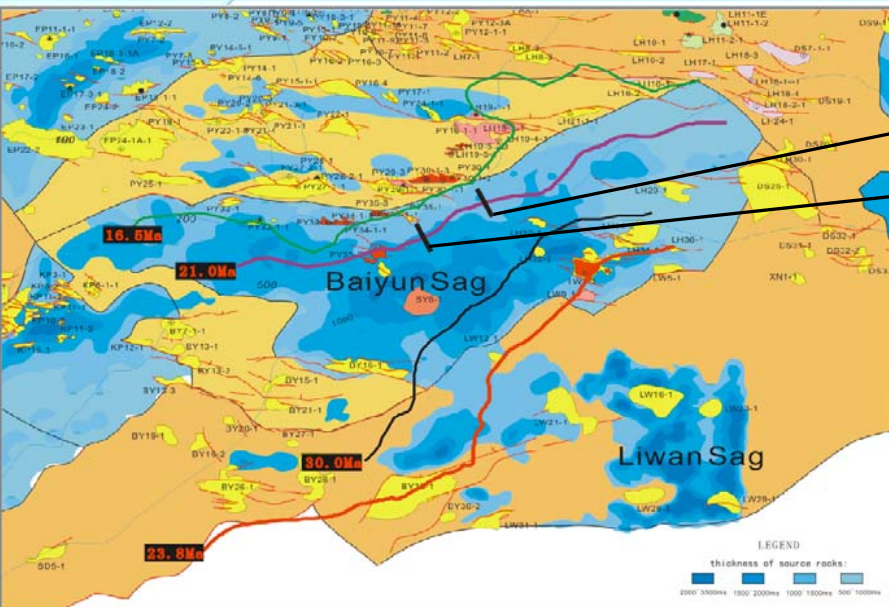


**Geographical location and tectonic pattern of the Pearl River Mouth Basin.**

The Baiyun sag is a subunit of the Pearl River Mouth Basin and is situated in the deepwater region on north slope of the South China Sea. By analyzing faults and sedimentary structures and combining analysis with a study of magmatism, the Baiyun sag is defined as a composite rift. Baiyun sag is also the largest sedimentary basin depression in the Pearl River Mouth Basin, located at the center of subsidence and deposition of Tertiary in the basin, and the maximum thickness of sediment is about 12km in Cenozoic, in which there are a huge reservoir sediment filling system and basic geological conditions for the migration and accumulation of oil and gas.



## 2. Retreating Shelf Break of Baiyun Depression from Oligocene to Miocene.



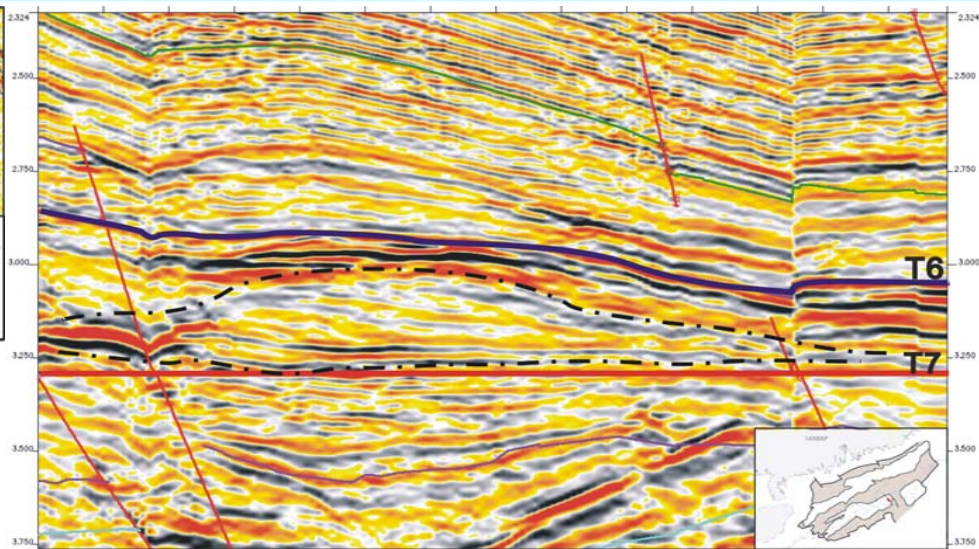
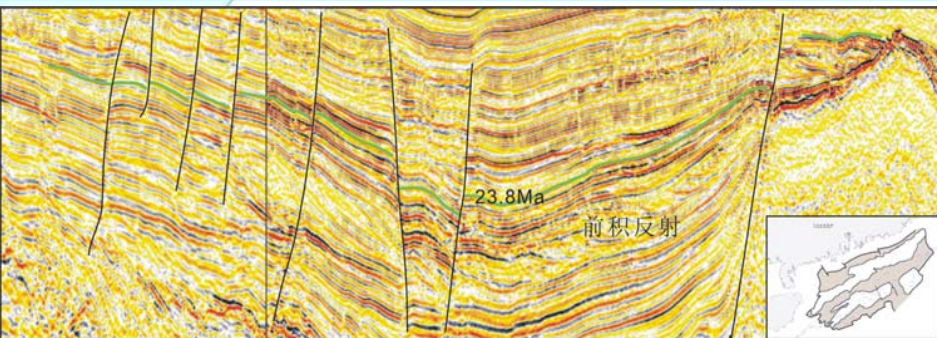
Retreating shelf break occurred from Oligocene to Miocene in deep water area of Baiyun depression, South China Sea, which controlled the development and distribution of sedimentation in the area. And, to some extent, it effected reserves form and distribution. Base on the latest drilling data, detail sedimentary analysis and meticulous interpretation of long cable, high quality, three dimensional seismic data, research of sedimentary response of retreating shelf break is carried out, meanwhile integrating the theories of shelf-margin delta, which indicated that the response of shelf break moving is shelf-margin delta progradational system of Zhuhai formation in Oligocene and growth faults complicating shelf-margin delta and deep-water fan system of Zhujiang formation. This discovery will benefit oil and gas exploration of Baiyun depression.

**Changes in the location of the shelf break in Baiyun sag from Oligocene to Miocene.**





### 3. Shelf Margin Delta Character In Zhuhai Formation.



**Classical shelf margin delta system progradational reflection on north-south, high-resolution seismic profiles of Baiyun sag.**

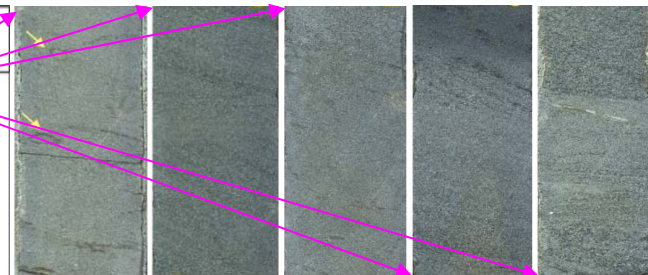
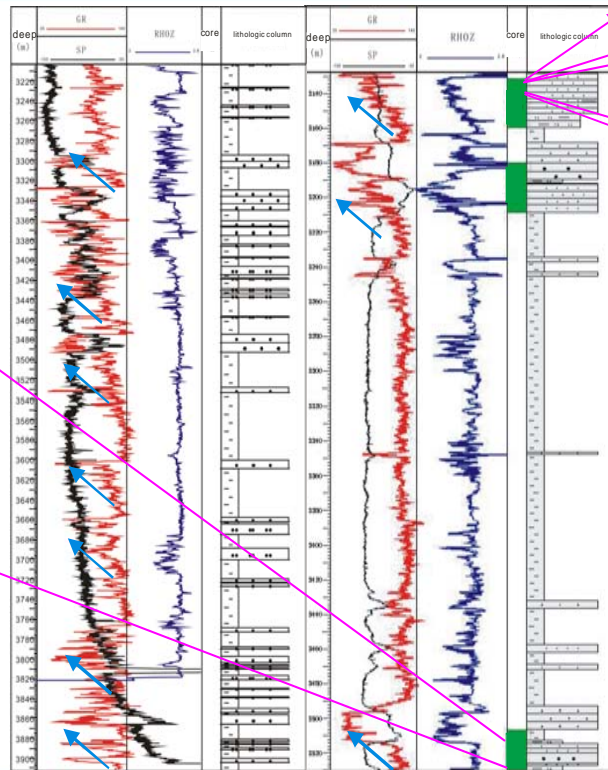
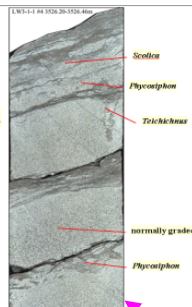
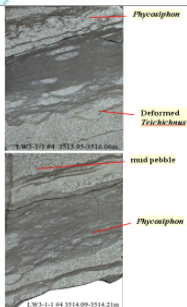
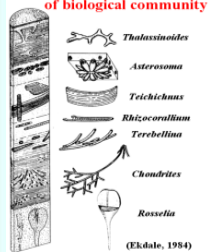
Seismic data analysis of Zhuhai formation reveal that deltas prograde primarily under late lowstand conditions and delta-front deposits were well developed. All these prove that the deltas prograde is formed in shelf break. And the large classic delta progradational reflection with wedges in both sides, which is also the distinct characters of shelf margin delta, can be found on north-south, high-resolution seismic profiles.



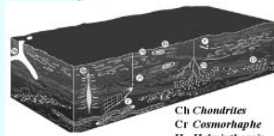


### 3. Shelf margin delta character in Zhuhai formation.

**Cruziana**: shallow trace fossils combination of biological community

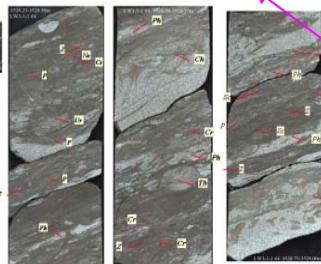


From the core analysis of Zhuhai formation in LW3-1-1, there is a transmutation from deep-sea sediments to gravity flow deposits, finally to shallow shelf deposition, which reveals the process that continental shelf margin delta prograded from continental shelf to slope and prompted slope-break zones moving to deep sea.



**Zoophycos**: bathyal trace fossils combination of biological community

- Ch Chondrites
- Cz Cosmorhaghe
- H Helminthopsis
- P Planolites
- Pa Palaeophycus
- Ph Phycosiphon
- Sc Scolicia
- Sp Spirographon
- Th Thalassinoides
- Z Zoophycos

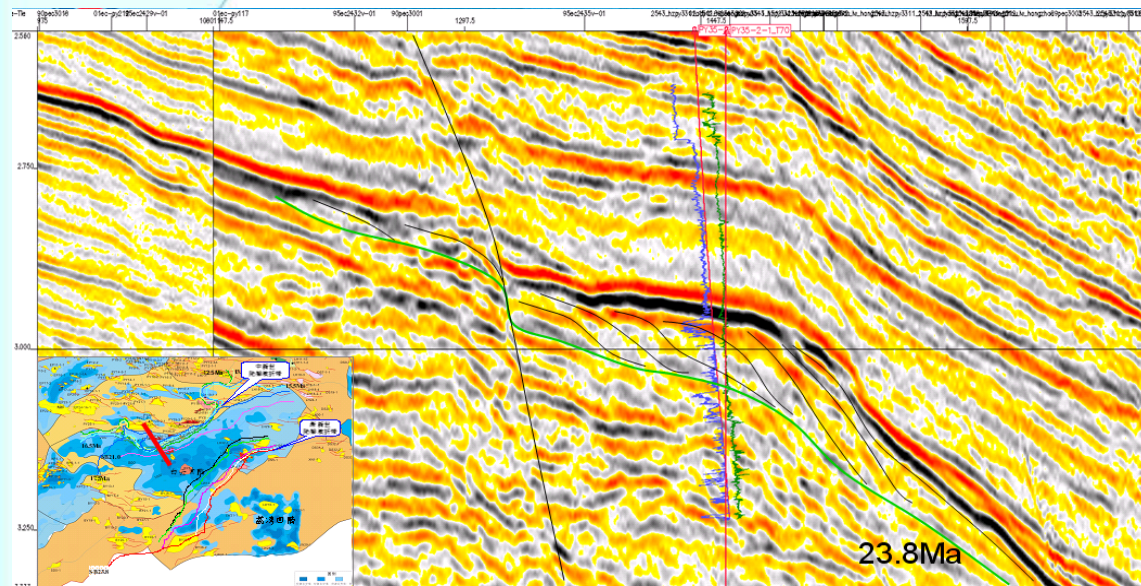


Well logs of LW3-1-1 Zhuhai formation (right) and LW3-1-2 Zhuhai formation (left).





## 4. Shelf margin delta character in Zhujiang formation.



**Classical shelf margin delta system progradational reflections on seismic profiles of Zhujiang formation, Baiyun sag.**

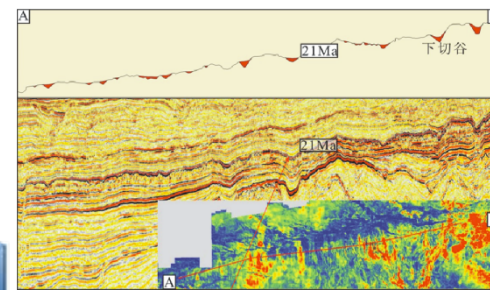
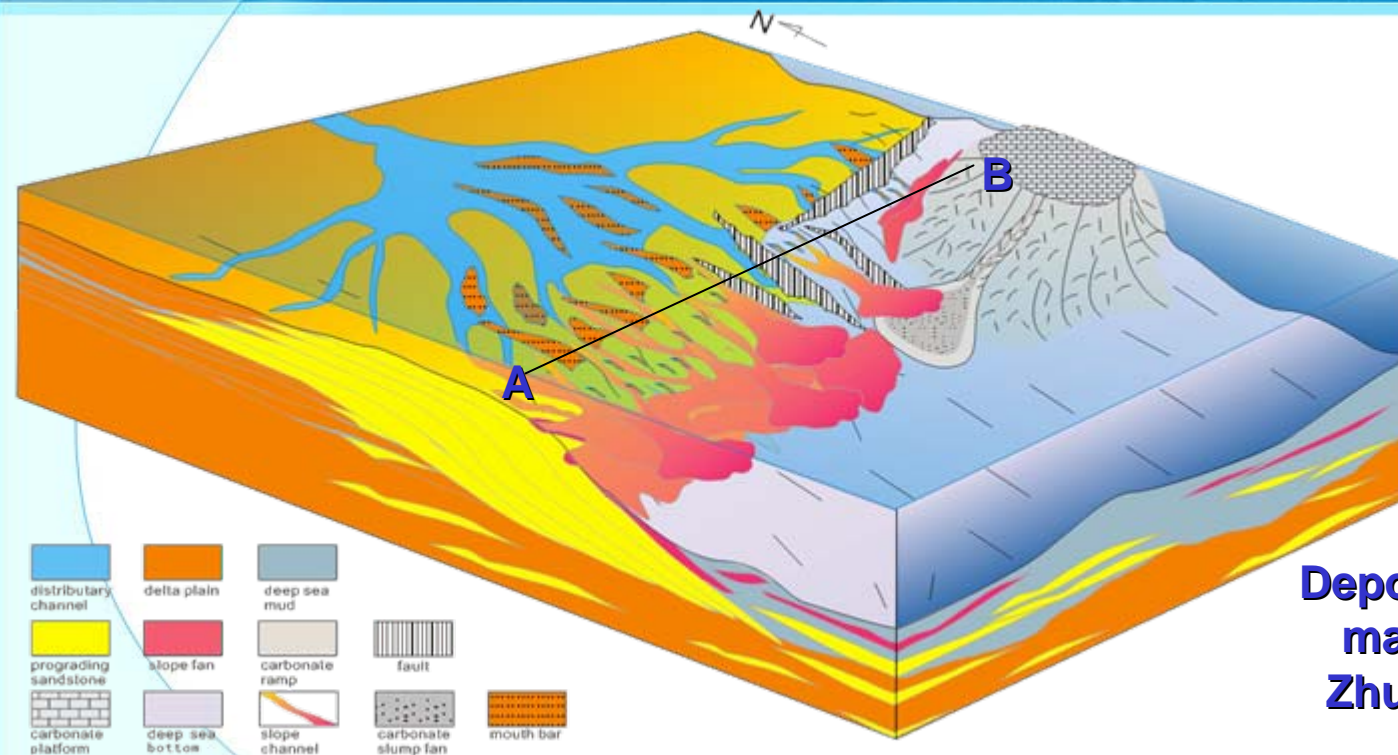
During Miocene, in contrast, depositional mechanism changed and there were more gravity-flow processes in the extended space between the outer shelf and upper slope. Accompanied by rising sea levels, Baiyun sag transformed into upper slope deep water environment. Although classic delta progradational reflection in Zhujiang formation is not as common as that in Zhuhai formation, in the north slope shelf break of Baiyun sag there are visible shelf margin delta progradational reflection.







## 4. Shelf margin delta character in Zhujiang formation.



**Deposition diagram of shelf margin delta system of Zhujiang formation in the Baiyun sag.**





## 5. Conclusion

The integrated data set and recently exploration results along the LH34 and the LH29 districts demonstrate the genetic link between the shelf margin deltas and the deepwater systems further basinward, indicating that there is huge exploration potential in Baiyun sag. But good reservoirs are always found along the shelf break direction, and in the vertical direction of the shelf break the sandstone are so poor and thin that can not be good reservoirs. The results demonstrate that shelf margin delta sandstone may become more important exploration targets than traditional deep water turbidity fan reserves systems. This trend is consistent with the latest research results. Therefore position of Shelf Break controlled the development and distribution of shelf margin delta sedimentation in the area, and to some extent, effected reserves form and distribution. So southward migration of shelf-margin in Oligocene may result shelf margin delta progradation reaching Liwan sag. And in Miocene Baiyun sag subsided rapidly that made slope-break migrated north and created a steeper slope. In north slope shelf break of Baiyun sag, a unique shelf-margin delta and deep-water fan system was formed. This finding will provide new ideas for oil and gas exploration in Baiyun sag, even all deep marine region of China. On the other hand, mix of clastic and carbonate sediment in this shelf margin delta system is very special. Therefore, the research on the formation mechanism of this phenomenon has great theoretical significance and practical value.



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***Thank you!***

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