#### The Hydrocarbon Migration and Accumulation Model of Shallow Layers in Sub-Sag, Slope and Salient of Continental Rift Basin: A Case Study of Huanghekou Sag in Bohai Bay Basin\*

Chen Lei<sup>1</sup>, Tian Lixin<sup>2</sup>, Zhou Xinhuai<sup>2</sup>, Niu Chengmin<sup>2</sup>, and Zeng Xuan<sup>2</sup>

Search and Discovery Article #10550 (2013)\*\*
Posted December 9, 2013

#### **Abstract**

Huanghekou sag which is a dustpan shape sag in the Cenozoic is a hydrocarbon-rich area in Bohai Bay Basin, with many large-scale extensional faults that provide a good pathway for the vertical migration of hydrocarbon. Up to now, over 600 million cubic meters of oil equivalent have been found here, while shallow layers is the main and mature exploration layers, the ratio of reserve is mostly 70%.

In order to keep a sustainable exploration in shallow layers, three different hydrocarbon migration and accumulation models are generalized: meshwork-carpet model in sub-sag, transfer station model in slope, and notching model in salient.

The meshwork-carpet model is made up of a three-layered structure: (1) the lower section is meshwork layers of oil source passages, which consist of many faults cutting in source rocks and providing hydrocarbon for shallow layers; (2) the middle section is storage layers, and it is glutenite of fluvial facies, with good connectivity, wide distribution and large thickness, which accumulates hydrocarbon from deep source rocks through faults; (3) the upper section is meshwork layers of hydrocarbon accumulation, including the faults cutting in storage layers and shallow sandbodies, through which hydrocarbon migrates and accumulates.

In the transfer station model, the subsea fan sandbodies deposited in the downthrow block of the large-scale extensional faults play an important role, and they could absorb most of the hydrocarbon produced in the hydrocarbon rocks, because of the large contact plane with the hydrocarbon source rocks; the episodic activities of the faults lead to the migration of hydrocarbon from sandbodies to shallow layers along the faults, which forms the reservoir.

In the notching model, hydrocarbon migrates from the high potential area in the slope to the low potential area in salient along faults, unconformity interfaces and sandbodies spatially, forming the stepped passage system; therefore, the shallow layers in salient is the final destination of accumulation.

<sup>\*</sup>Adapted from oral presentation presented at AAPG Annual Convention and Exhibition, Pittsburgh, Pennsylvania, May 19-22, 2013

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In recent years, many shallow fields have been found from sub-sag to salient with reserve of 150 million cubic meters under the guidance of the three models, which are also a great help to the exploration in the similar continental rift basin.

#### **Selected Reference**

Zhang, S., and J. Zeng, 2003, An experimental study on the influence of faults on petroleum migration and accumulation in the Guantao Formation in the Zhanhua Depression, Shandong, China: Earth Science Journal of China University of Geoscience, v. 28/2, p. 185-190.



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Bohai Oilfield Exploration and Development Institute CNOOC Ltd. -Tianjin, China

May 20, 2013



### **Outline**

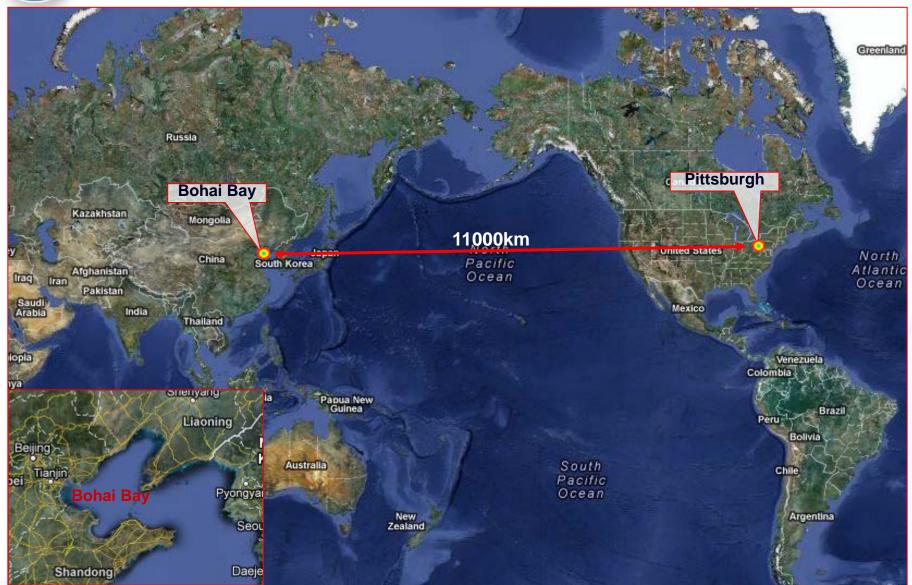


- Geological Background
- ◆ Three Kinds of Hydrocarbon Migration and Accumulation Models of Shallow Layers
- Exploration Significance



#### **Geographical Location**

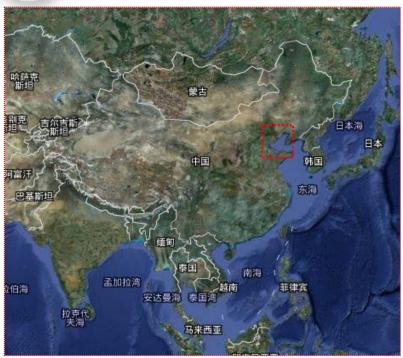






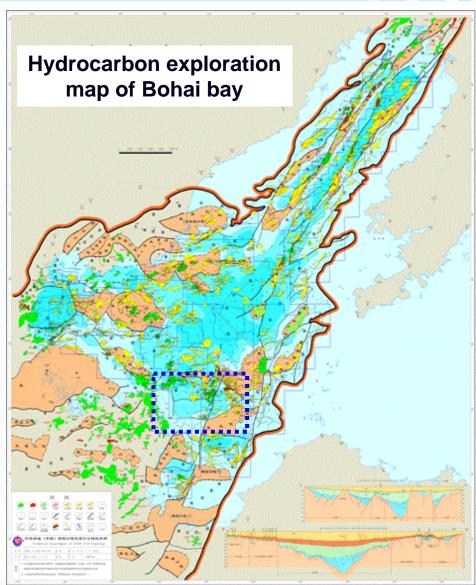
#### **Regional Location**





**Geographical location map** 

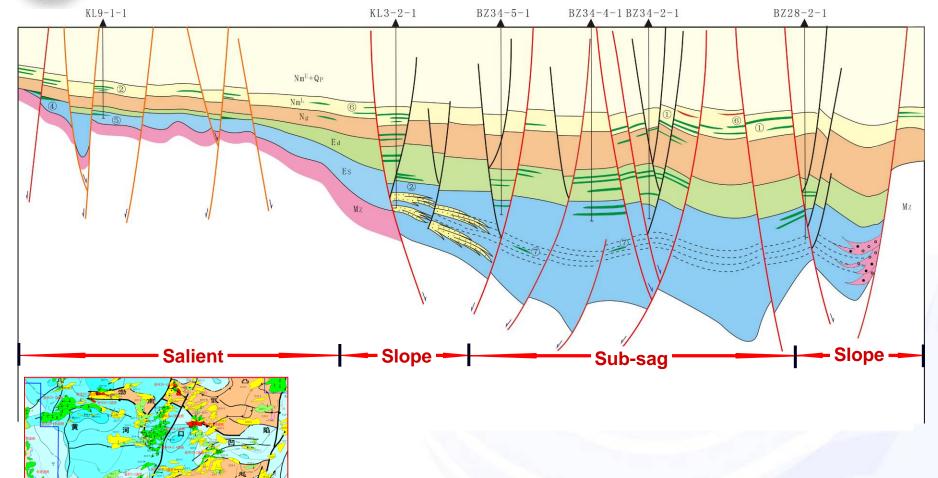
Bohai bay basin is a continental rift basin in Cenozoic ,with the area of 20 0000 km<sup>2</sup>. And Huanghekou sag is one of the hydrocarbon-rich sags in the south of Bohai Bay basin, with the area of about 3300km<sup>2</sup>.





#### **Sag Structure**



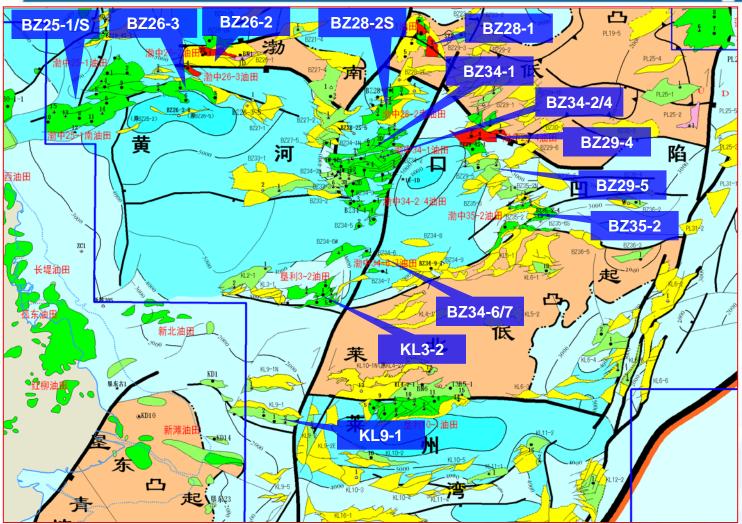


Huanghekou sag is a dustpan shape sag, which is made up of three parts.



#### Oil and Gas Exploration Results





The oil and gas exploration began in 1979 in this sag. Up to now, 13 large and medium-sized oil and gas fields have been discovered with over 600 million cubic meters of oil equivalent, while shallow layers are the main and mature exploration layers, the ratio of reserve is mostly 70%.



## **Outline**

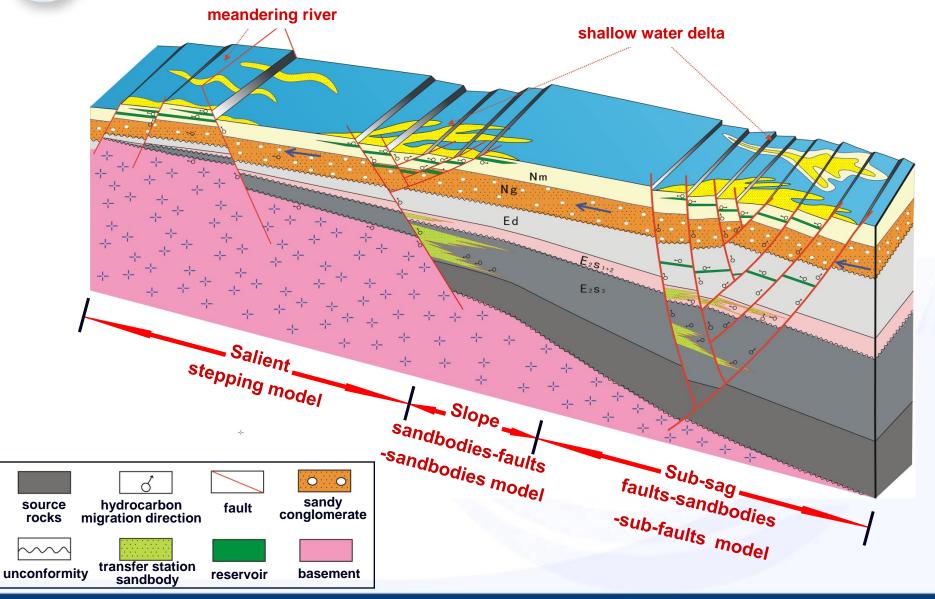


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#### Hydrocarbon Migration and Accumulation Models

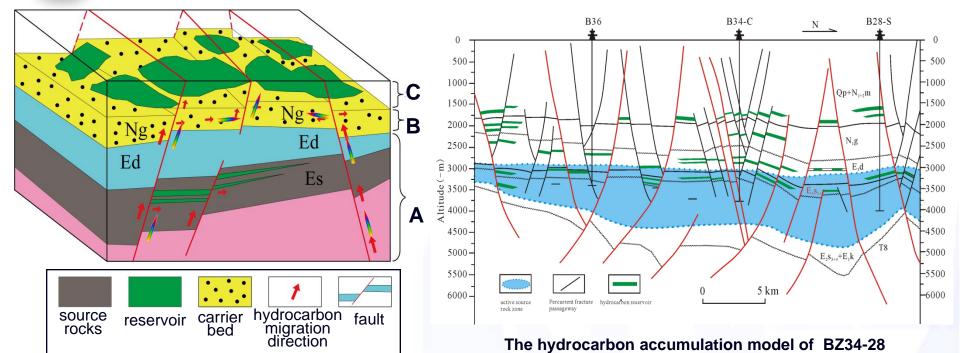




CNOOC



#### 1. The Faults-Sandbodies-Sub-faults Model in Sub-sag



structural belt in Huanghekou sag

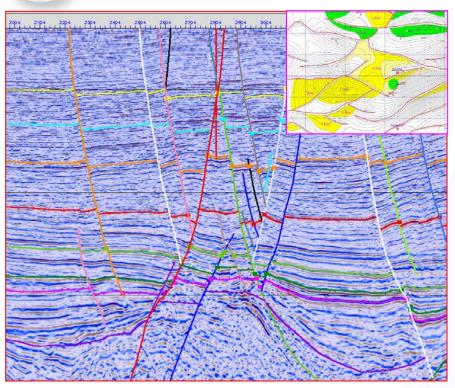
This model is made up of three-layered structure: (A) the lower section is meshwork layers of oil source passages which consist of many faults cutting in source rocks and providing hydrocarbon for shallow layers; (B) the middle section is storage layers, and it is glutenite of fluvial facies, with good connectivity, wide distribution and large thickness, which accumulates hydrocarbon from deep source rocks through faults; (C) the upper section is meshwork layers of hydrocarbon accumulation, including the faults cutting in storage layers and shallow sand bodies through which hydrocarbon migrates and accumulates.

The faults-sandbodies-sub-faults model (Zhang Shanwen, et al, 2003, Shengli oilfield)

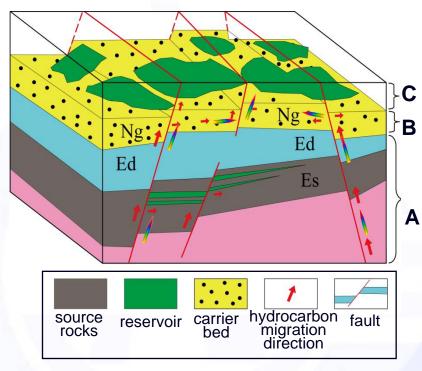


#### **Different Research Thought**





The traditional research thought



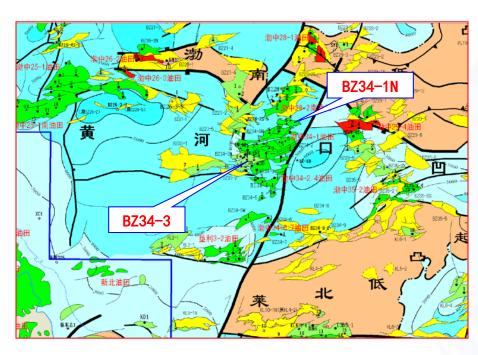
The faults-sandbodies-sub-faults model

There are some differences between the traditional research and the faults-sand-bodies-sub-faults model research. Traditional research pays attention to the large faults and the shallow structural traps, while the faults-sand-bodies-sub-faults model research pays attention to the faults cutting in storage layers and the shallow sand-bodies.

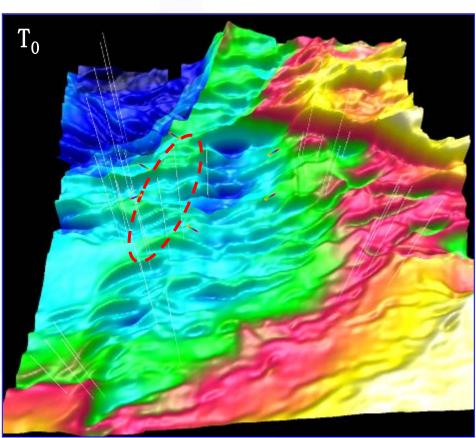


#### **Successful Cases**





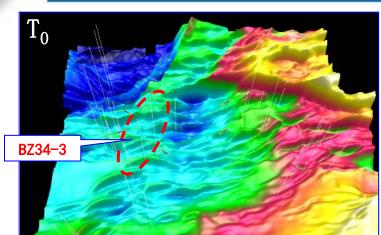
Hydrocarbon exploration map of Huanghekou sag

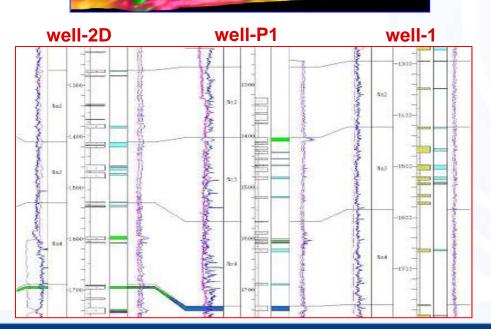


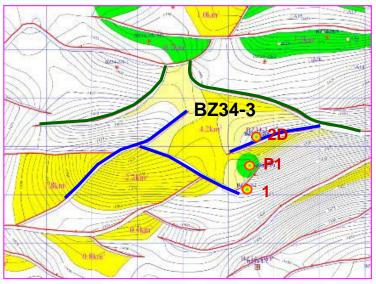
The ancient landform map of  $N_1g$ 



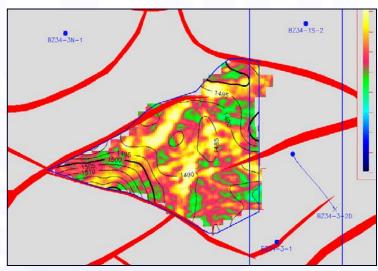
# BZ34-3 Oilfield in Structural Ridge







The structural map of shallow layers

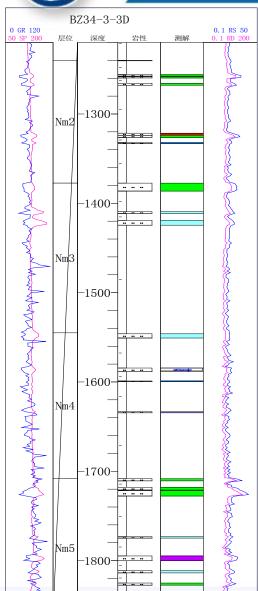


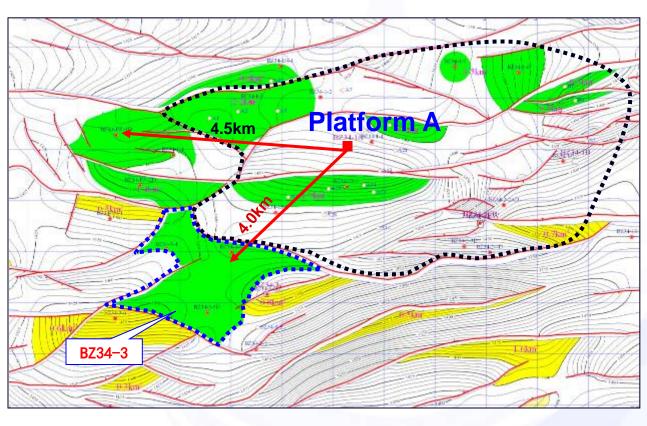
The sandbody of N₁m<sup>L</sup>



### **BZ34-3 Oilfield in Structural Ridge**





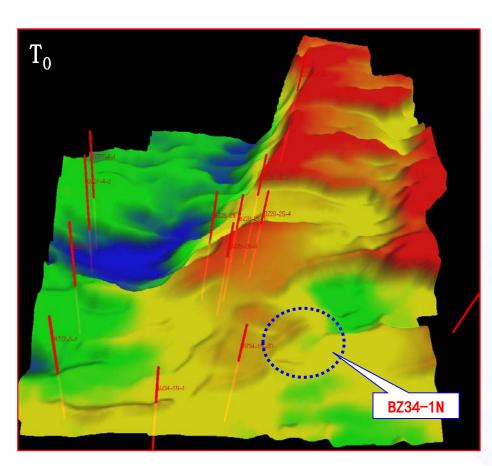


The structural map of shallow layers

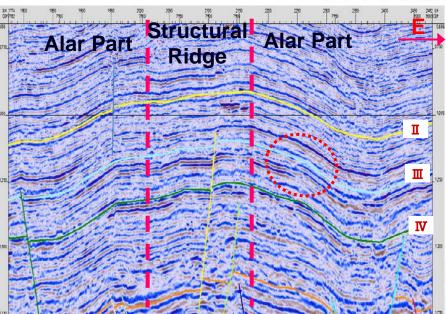


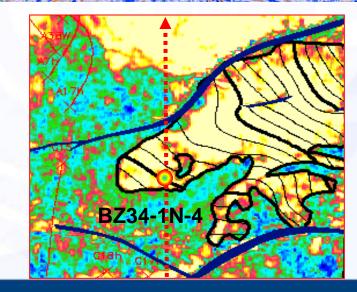
#### **BZ34-1N in Alar Part**





The ancient landform map of  $N_1g$ 

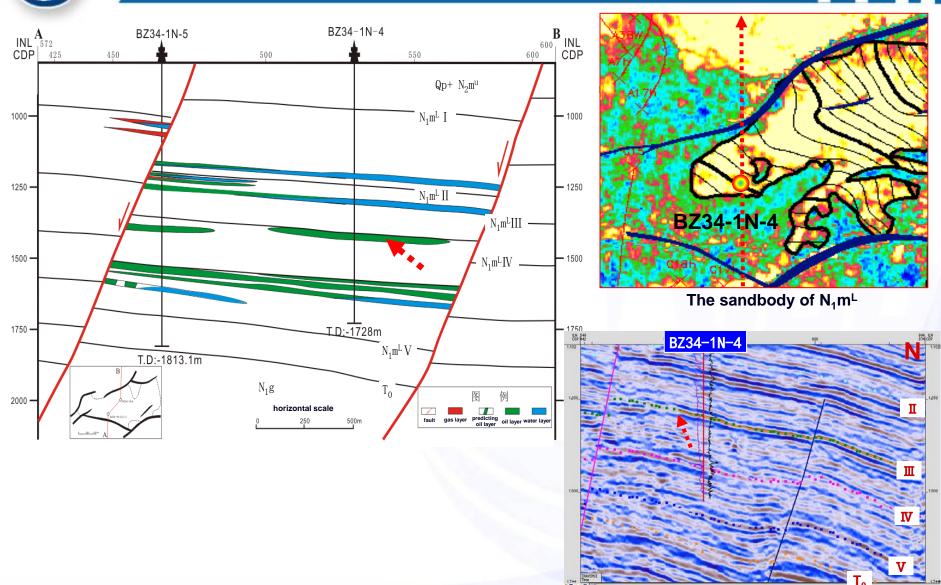






#### **BZ34-1N in Alar Part**

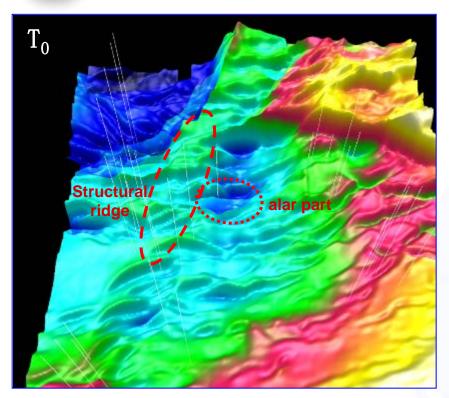


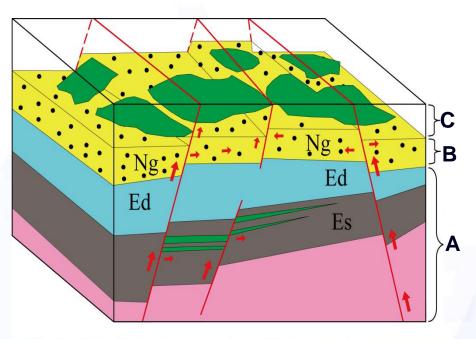




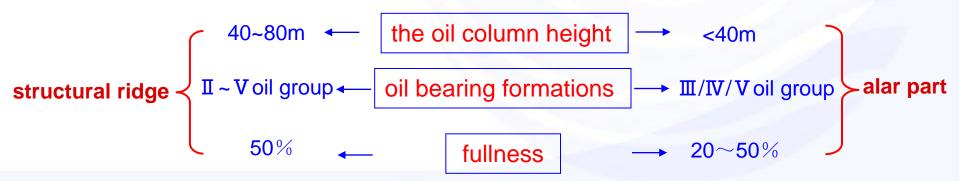
#### **Laws of Hydrocarbon Accumulation**





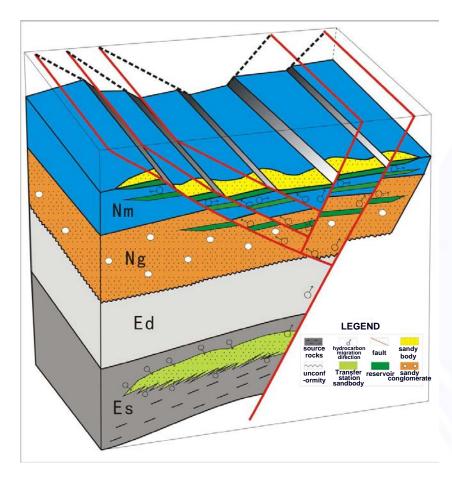


The meshwork-carpet model map



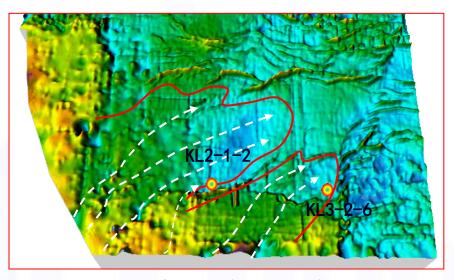






The sandbodies-faults-sandbodies model map

(Deng Yunhua, 2005, CNOOC)



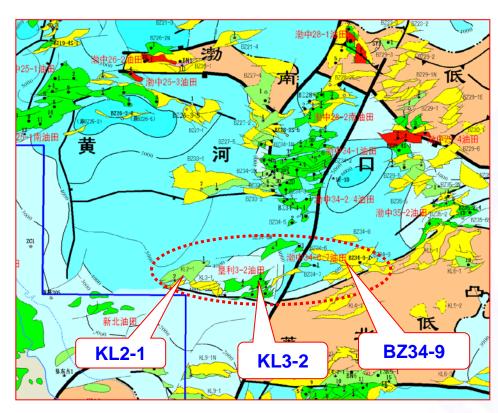
The ancient landform map of  $E_2 s_{1+2}$ 

In this model, the subsea fan sand-bodies deposited in the down throw block of the large-scale extensional faults play an important role. They could absorb most of the hydrocarbon produced in the hydrocarbon rocks because of the large contact plane with the source rocks. The episodic activities of the faults lead to the migration of hydrocarbon from sand-bodies to shallow layers along the faults which form the reservoir.

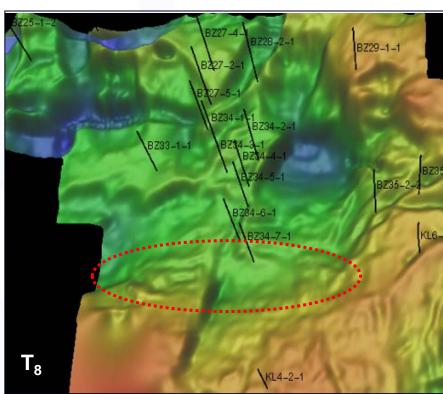


#### **Successful Cases**





Hydrocarbon exploration map of Huanghekou sag

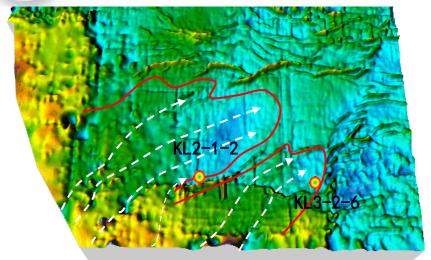


The ancient landform map of tertiary

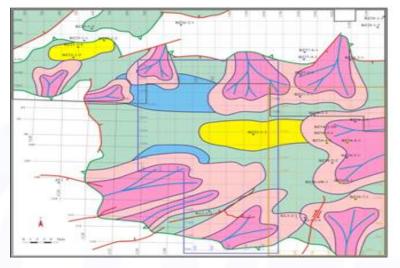


#### **KL2-1 Hydrocarbon Bearing Structure**

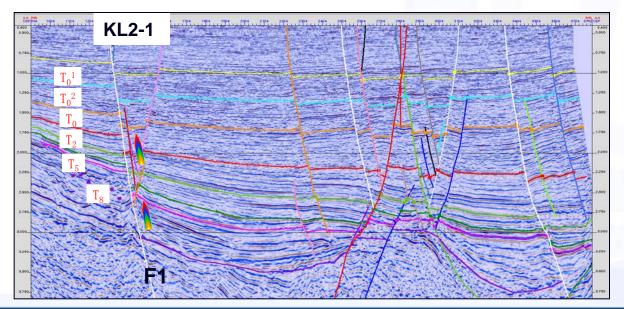


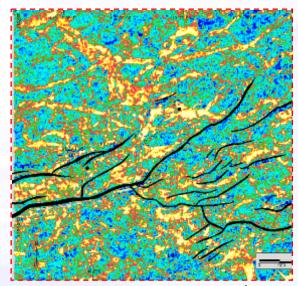


The ancient landform map of  $E_2s_{1+2}$ 



The sedimentary facies map of E<sub>2</sub>s<sub>1+2</sub>





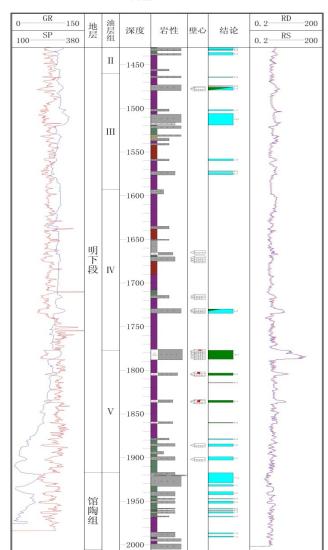
The sandbody of  $N_1 m^L$ 

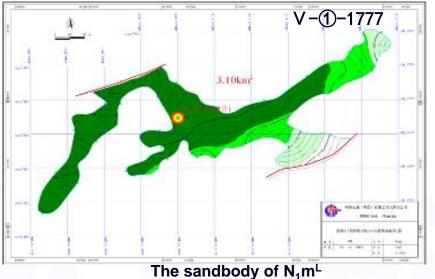


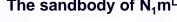
#### **KL2-1 Hydrocarbon Bearing Structure**

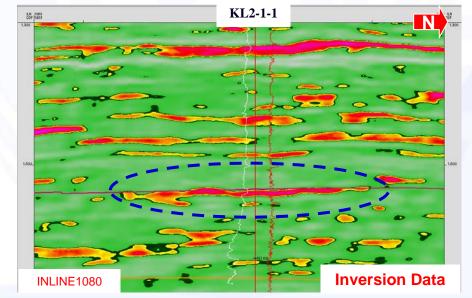








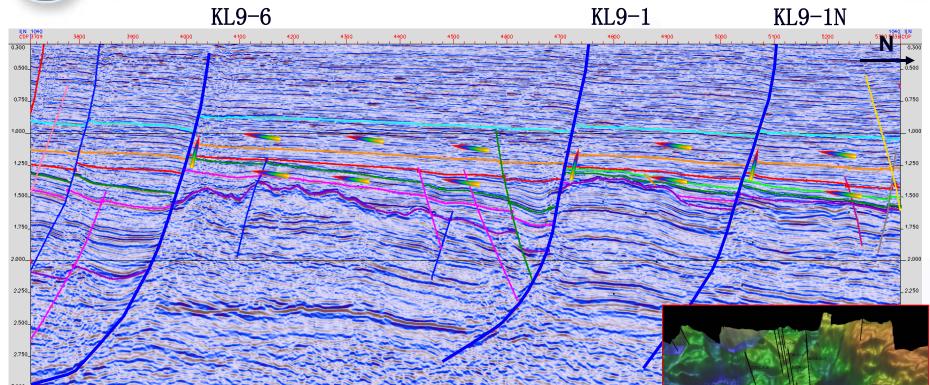






#### 3. The Stepping Model in Salient



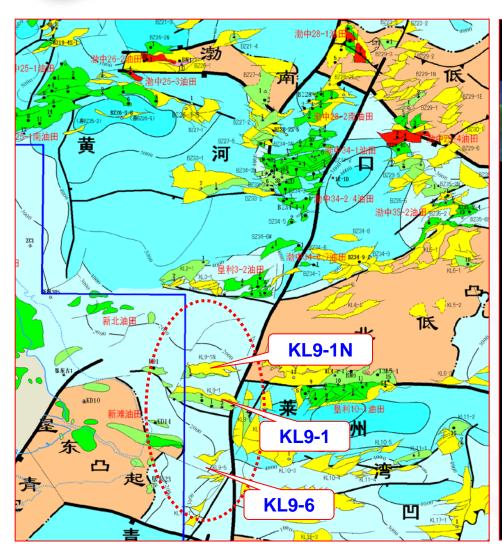


In this model, the hydrocarbon migrates from the high potential area in slope to the low potential area in salient along faults, unconformity interfaces and sandbodies spatially, forming the stepping passage system; therefore, the shallow layers in salient is the final destination of accumulation.



#### **Successful Cases**





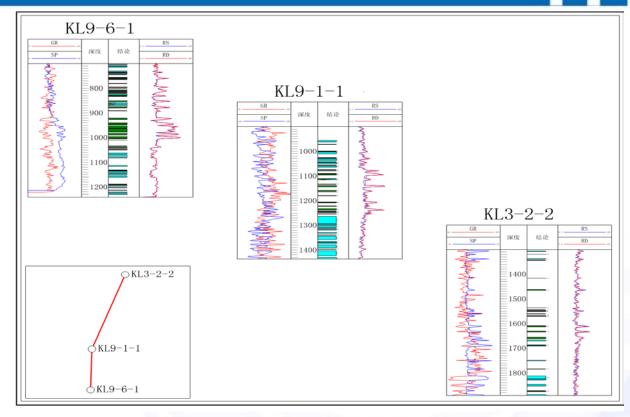
Hydrocarbon exploration map of Huanghekou sag

The ancient landform map of tertiary









well	KL9-6-1	KL9-1-1	KL3-2-2
oil-bearing horizons/-m	735-1040	999-1255	1462-1661
thickness of oil and gas layers/m	80. 2	52. 5	20. 4
density/g/cm³(20℃)	0. 989	0. 938	0.869
viscosity/mPa.s (50℃)	1573. 38	142.38	13.66



### **Outline**

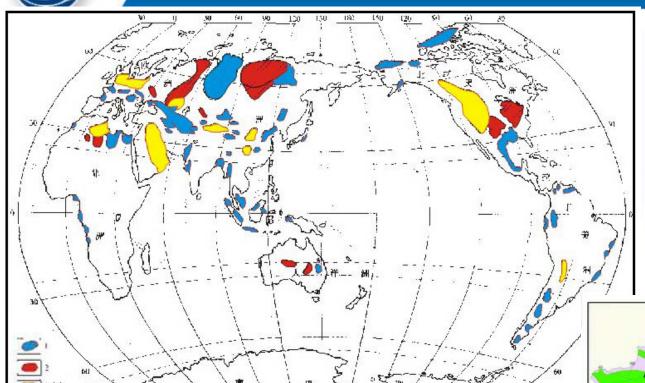


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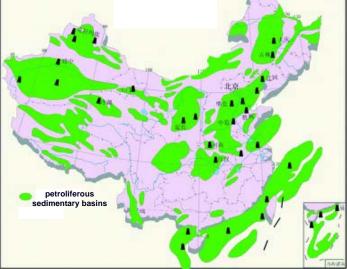
#### **Exploration Significance**





#### Distribution map of the world's major petroliferous sedimentary basins (Gan Kewen, et al. 1982, simplify and modify)

1、 oil producing basin in Cenozoic and Mesozoic; 2、 oil producing area in Palaeozoic; 3、 oil producing basin in Palaeozoic to Cenozoic.



Distribution map of Chinese major oilfield



#### **THANK YOU FOR YOUR TIME!**

For further discussion:

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