[PS]The Keys to New Sub-Igneous Oilfield Discovery in Offshore Bohai Bay Basin, China*

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Abstract

Oil and gas exploration to sub-igneous structures in offshore Bohai Bay Basin began in the 1970s and a series of oil and gas bearing structures have been found over forty years, but no commercial sub-igneous reservoir had been discovered until 2015. In recent years, commercial sub-igneous reservoirs were first discovered in the southern slope of Huanghekou sag, with reserves of 80 million cubic meters. The key factors to the breakthrough discovery of gas mainly rests with the following aspects: (1) The background of uplift was formed under the action of magmatic diapir and strike-slip extrusion in the slope, which is a favorable direction of hydrocarbon migration and accumulation, (2) with magmatism in the Late Oligocene, large scale of basalt and tuff distributed widely, which is a good regional capping layer for oil and gas, (3) the volcanic channel facies developed in fissure eruption mode is a good lateral sealing layer of oil and gas, which is extremely favorable to form a high hydrocarbon abundance zone, and (4) early magmatic activity formed an alkaline water environment, which was favorable to preserve primary pores, while late hydrocarbon generation and expulsion of organic acid fluid formed an acidic water environment which was favorable to the development of the secondary pores. The igneous rock developed widely in Bohai Bay Basin, with the distribution area of more than 60%, which is good for looking for sub-igneous reservoirs. Therefore, the breakthrough discovery of commercial sub-igneous oil and gas provides a great reference to oil and gas exploration.

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The keys to new sub-igneous oilfield discovery in offshore Bohai Bay Basin, China

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Abstract: The oil and gas exploration to sub-igneous structure in offshore Bohai Bay basin began in the 1970s, a series of oil and gas bearing structures have been found in forty years，but no commercial sub-igneous reservoir has been discovered until 2015.

In recent years, commercial sub-igneous reservoir was firstly discovered in the southern slope of Huanghekou sag, with the reserves of 80 million cubic meters. The key factors to the breakthrough discovery of gas mainly rest with the following aspects: (1)The background of uplift was formed under the action of magmatic diapir and strike slip extrusion in the slope，which is a favorable direction of hydrocarbon migration and accumulation. (2)As the activities of magmanism in the late Oligocene, a large scale of basalt and tuff distributed widely, which is a good regional capping layer of oil and gas. (3)The volcanic channel facies developed in fissure eruption mode is a good lateral sealing layer of oil and gas, which is extremely favorable to form a high hydrocarbon abundance zone. (4)Early magmatic activity formed an alkaline water environment, which was favorable to preserve primary pores, while late hydrocarbon generation and expulsion of organic acid fluid formed an acidic water environment, which was favorable to the development of the secondary pores.

The igneous rock developed widely in Bohai Bay basin, with the distribution area of more than 60%, which is good for looking for sub-igneous reservoirs. Therefore, the breakthrough discovery of commercial sub-igneous oil and gas provides a great reference to oil and gas exploration.

1. Geological setting

Huanghekou sag is located in the south of Bohai Bay Basin and is a half-graben with steep dip angle in the north limb and gentle in the south developed on the Mesozoic basement. The Tan-lu fault belt passes Huanghekou sag by the West branch faults, which were characterized by the most complicated and most typical NNE dextral strike-slip fractrue belt.

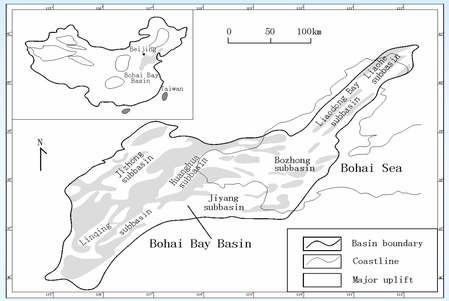

Fig.1 Study area location of Bohai Bay Basin

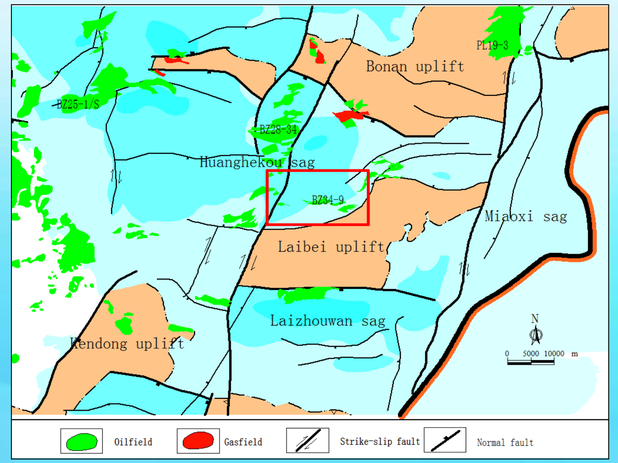

Fig.2 The regional location of Huanghekou sag

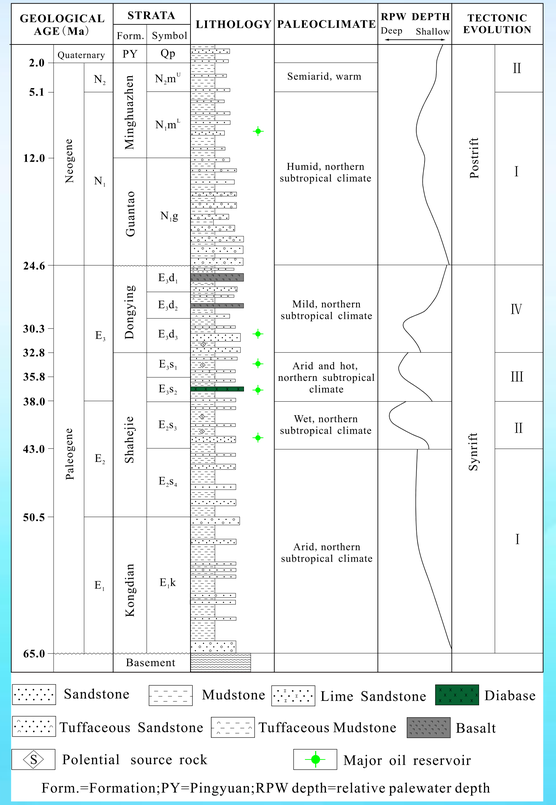

Fig.3 The sequence stratigraphy column in Huanghekou sag

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2. The geological characteristics and models of volcanic eruption

In the Oligocene, crust thinning and strong right-lateral strike-slip trigger large-scale volcanic eruptions in the study area.

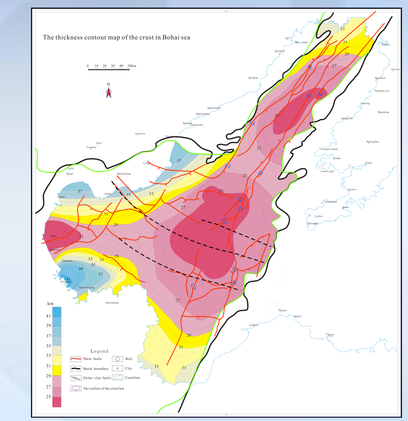


Fig.4 Overlay map of crustal thickness and fault distribution in Bohai sea area

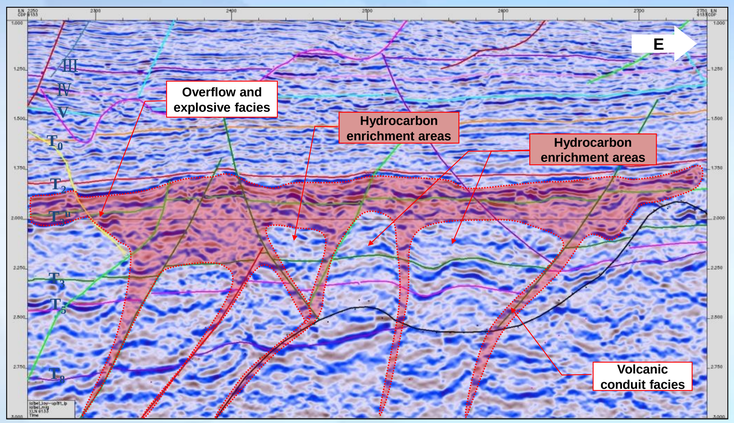


Fig.5 The igneous rock distribution in the seismic reflection profile

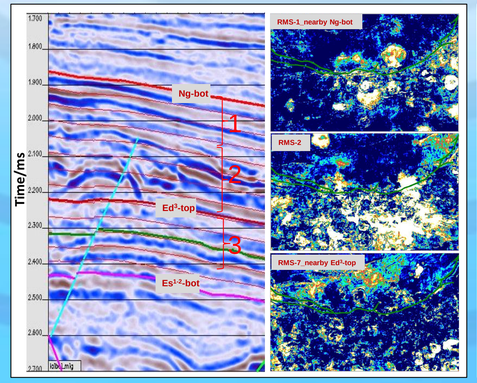


Fig.6 Seismic attribute show the distribution of magmatic rock in BZ34-X oilfield

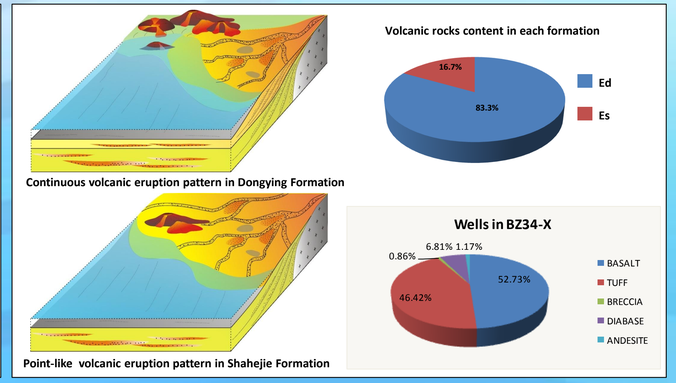
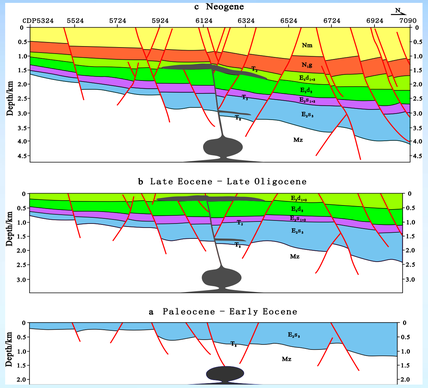


Fig.7 Continuous volcanic eruption pattern in Ed and point-like volcanic eruption pattern in Es

3. The fault and magma joint control on hydrocarbon accumulation

3.1 The fault and magma combination controls the formation of uplift zones on the slope and development of sizable traps .



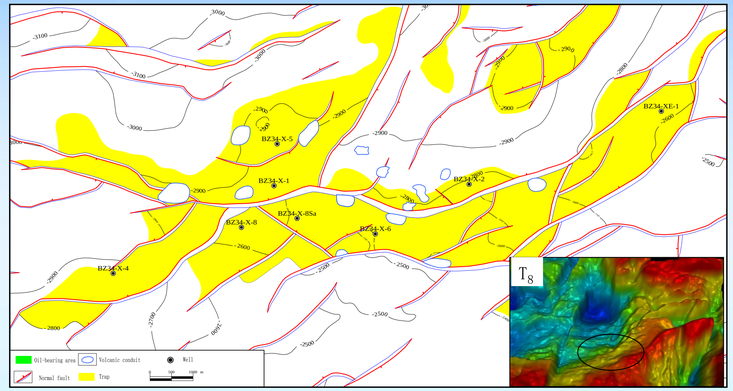


Fig.8 Tectonic evolution, magmatic development and trap characteristics at top of Es_3 in Paleogene in BZ34-X area

3.2 The spatial and temporal relationship between faults and magma benefits the development of deep buried good reservoirs.

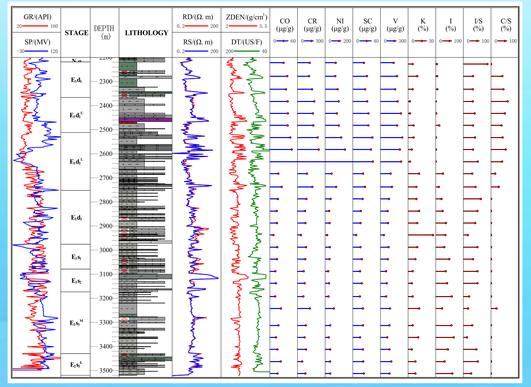


Fig.9 Trace elements and clay mineral content in igneous strata

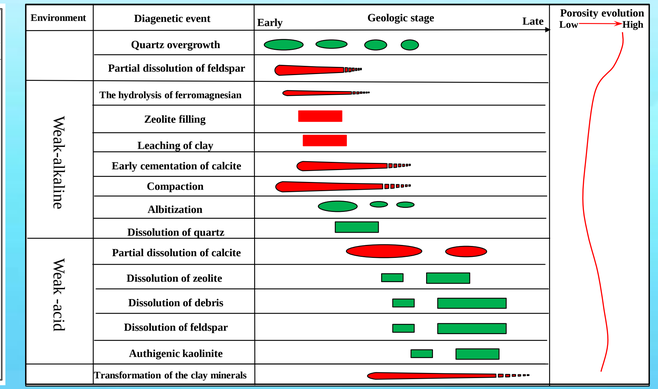


Fig.10 Diagenetic event and evolution in BZ34-X area

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- The ordered coupling of magmatic eruption and faults in syn-deposit period is conductive to the formation of high-quality reservoirs.

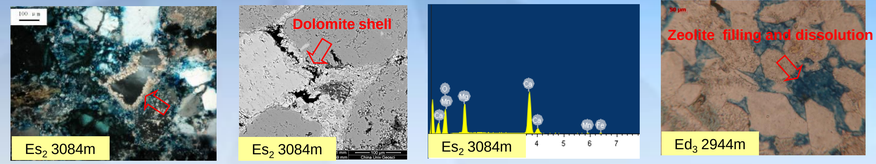

Fig.11 Mineral characteristics forming in the Alkaline water setting

- Volcanic conduit and overflow igneous rock forms the “pier effect”, which can stand compaction and benefit the preservation of deep buried good reservoirs.

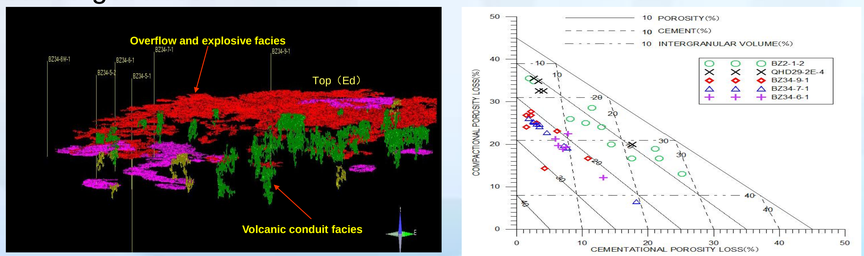

Fig.12 3-D view of volcano organization in Paleogene and Fig.13 Porosity reduction ratio in Paleogene of Bohai Sea (a uniform depth)

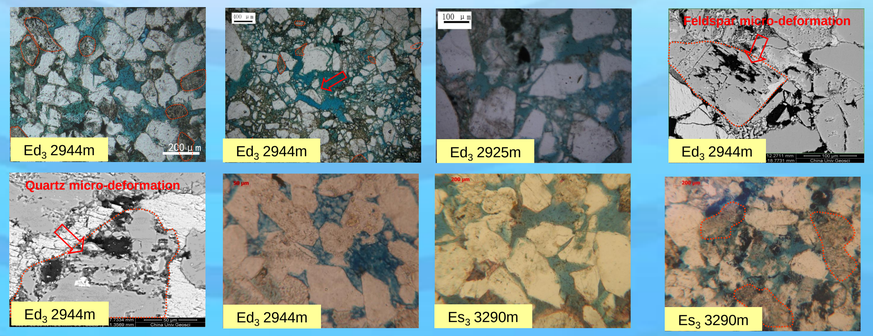

Fig.14 The point-contact between rock particles in volcaniclastic rock reservoir of Paleogene

3.3 The fault and magma coupling controls the differences of hydrocarbon accumulation

- Pulsing magmatic activities and episodic faults’ activities control the hydrocarbon enriched blocks.
- The effective coupling of blank space in magmatic rocks and migration faults controls the hydrocarbon accumulation in shallow layers.
- Approximately 73% of oil reserves in Paleogene and 27% in Neogene have been found in BZ34-X oilfield.

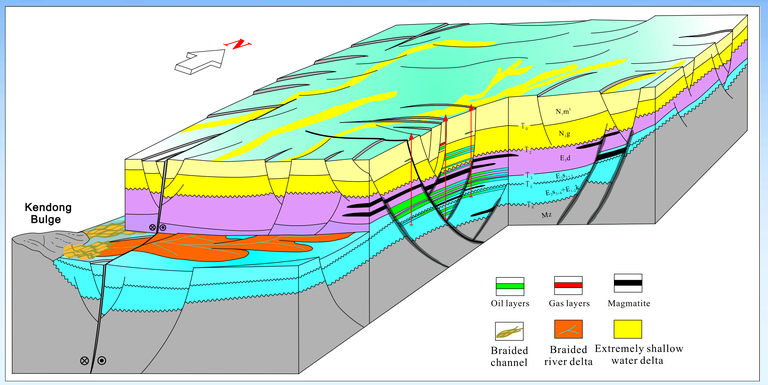

Fig.15 Gas and oil accumulation in igneous rock areas of BZ34-X oilfiled

4. Exploration effectiveness

- Crude oil density:0.850～0.918g/cm^3
- Crude oil viscosity:5.61～61.54mPa·s
- Maximum production: 287.9m^3/d

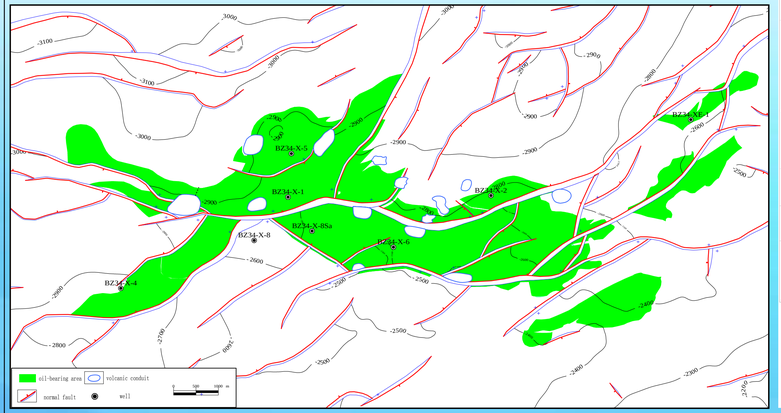

Fig.16 The oil bearing areas of BZ34-X oilfield

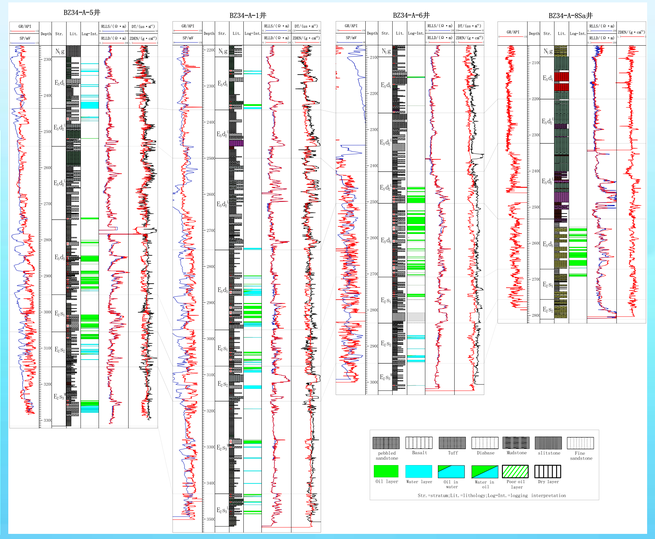

Fig.17 Cross-well correlation and oil-bearing property in BZ-X oilfield