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

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Search and Discovery Article #10945 (2017)**
Posted May 29, 2017

*Adapted from poster presentation given at 2017 AAPG Annual Convention & Exhibition, Houston, Texas, April 2-5, 2017
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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.
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 Tanlu 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.
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.

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.

3.2 The spatial and temporal relationship between faults and magma benefits the development of deep buried good reservoirs.
The ordered coupling of magmatic eruption and faults in syn-deposit period is conductive to the formation of high-quality reservoirs.

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

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.

4. Exploration effectiveness

- Crude oil density: 0.850 ~ 0.918/cm³
- Crude oil viscosity: 5.61 ~ 61.54/mPa·s
- Maximum production: 287.9/m³/d