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## The Characteristics and Genetic Types of Tight Sandstone Reservoir in the First Member of Funing Formation in Gaoyou Sag, Subei Basin

ZHOU Lei<sup>1\*</sup>, LU Shuangfang<sup>1</sup> and YU Wenquan<sup>2</sup>

<sup>1</sup> China university of petroleum, Qingdao, Shandong 266580, China

<sup>2</sup> Geological Scientific Research Institute of Jiangsu Oilfield Company, SINOPEC, Yangzhou, Jiangsu 225009, China

### 1 Introduction

Gaoyou Sag locates in the southern of Subei Basin, in which south is Tongyang Uplift, and connects with Jianhu Uplift and Zheduo Low Uplift in the north, began with Beiju Depression in the east, connects with Wubao Low Uplift and Qintong Depression in the southeast, links with Lingtanqiao Low Uplift and Jinhu Depression in the west. Gaoyou Sag shows long strip distribution in SE and area of 2670km<sup>2</sup>, which east-west distance is about 100km, and the south-north is about 25~30km. The Cenozoic sedimentary thickness in Gaoyou Sag is about 7000m, which is the deepest in Subei Basin, and can be divided into slope belt of the northern, sub-sag belt of the center and fault-step belt of the southern. In recent years, tight oil were found in Funing formation of Paleogene in the northern slope belt and the southern fault-step belt, and the most widely distribution were in the first member of Funing formation. As a result of the complexity of characteristics and genetic mechanism of tight reservoir, the part of exploration wells were loss. Therefore, it is necessary to defining the characteristics and analyzing the genetic mechanism of tight reservoir for the high efficient exploration and development of tight oil pool.

### 2 Characteristics of Tight Sandstone Reservoir

#### 2.1 Characteristics of lithology and petrophysical property

The tight reservoir in E<sub>1</sub>f<sub>1</sub> formed in deltaic environment (Wu Siyi, et al., 2014), the rock types are mainly feldspathic lithic sandstone and lithic arkose sandstone, with finer grained, high cement content, low component maturity and structure maturity, moderate sorting and poor rounding. The reservoir with an average porosity of 8.42%, average permeability of 0.35~0<sup>-3</sup>μm<sup>2</sup>, which porosity less than 10%

accounting for 52.2% and permeability less than 1×10<sup>-3</sup>μm<sup>2</sup> accounting for 74.1%. Based on the analysis of casting thin sections and argon ion polishing SEM, reservoir of E<sub>1</sub>f<sub>1</sub> developed various types of reservoir space, such as secondary pore, primary pore and intergranular micropore, of which the feldspar and debris dissolution pores developed widely, accounting for 86% of the total porosity, quartz particles dissolution pores accounted for about 2.6%, primary pores accounted for about 16.4%, and clay mineral intercrystal pore accounted for about 3%.

#### 2.2 Characteristics of diagenesis

The diagenesis types of tight reservoir of E<sub>1</sub>f<sub>1</sub> in Gaoyou Sag mainly include compaction, cementation, dissolution and metasomatism (Zhang Jinliang, et al., 2003). Due to deeply buried, finer grained of tight sandstone and the lower maturity, compaction is generally strong, show directional arrangement on the long axis of the particles and line-bump contact. Cementation is given priority to with carbonate cementation, plus a little of siliceous cementation, Clay mineral cementation and pyrite cementation in the study area. Carbonate cements mainly include ferroan calcite and ferroan dolomite, which with an average content of 8.21% and show porous cementation generally, the content of calcite and dolomite are less, with an average content of 4.9% and show porous cementation and basal cementation. Siliceous cementation generate in the form of quartz overgrowth, which show metasomatism with carbonate and with an average content of 0.85%. Clay mineral cementation is given priority to with illite-montmorillonite mixed-layer, illite and kaolinite, I/S mixed-layer mineral mainly generate in the form of pore filling and pore lining, kaolinite exist among most intergranular pore of particle in various degrees, part of the kaolinite fill in the throat and reduce the throat width.

#### 2.3 Controlling Factors of Petrophysical Property

Reservoir petrophysical property in the study area is essentially controlled by sedimentation and diagenesis, the

\* Corresponding author. E-mail: zhoulaiupc@163.com

former is the key factor that affecting reservoir physical properties. Reservoir of  $E_1f_1$  is given priority to with siltstone and fine sandstone, formed in delta front environment, and sedimentary microfacies included underwater distributary channel, mouth bar, sheet sand and underwater distributary bay. According to petrophysical data analyzing, From high to low, the value of reservoir porosity and permeability of the microfacies are in turn distributary interchannel, mouth bar, sheet sand and underwater distributary bay, underwater distributary channel sand and mouth bar sand that with coarse particle size and thicker thickness have better reservoir petrophysical property than sheet sand and underwater distributary bay sand that with finer particle size and thinner thickness. Therefore, the differentiation of original petrophysical property that caused by sedimentation will expand under the late diagenesis further. Obvious affect to reservoir petrophysical property that caused by diagenesis include compaction, cementation and dissolution, even the compaction is the main causes of tightness. It is not hard to find that porosity that reduced by compaction are worse than reduced by cementation, because the rate of porosity reducing caused by compaction are between 50% with 70% ,with an average value of 58.8%, while the rate of porosity reducing caused by cementation are between 5% with 38% ,with an average value of 19.5%. For the reason of dissolved pore accounted for over 70% of the total porosity, dissolution increased the reservoir petrophysical property effectively. As a whole, There are three types of diagenetic sequence that generated in the reservoir of  $E_1f_1$  in Gaoyou, firstly, compaction-weaker carbonate cementation-weaker dissolution of feldspar and rock debris-weaker hydrocarbon injection-ferriferous carbonate cementation-pyrite cementation. Secondly, compaction-quartz overgrowth-stronger carbonate cementation-ferriferous carbonate cementation-pyrite cementation. Thirdly, compaction-quartz overgrowth-weaker carbonate cementation-dissolution of feldspar and rock debris-hydrocarbon injection-ferriferous carbonate cementation-pyrite cementation. The third diagenetic sequence is the mainly type that exist in the study area.

## 2.4 Fluid-inclusion analysis

According to the statistics of homogenization temperature of saline inclusion, diagenetic environment of the first member of Funing formation( $E_1f_1$ ) were recovered. The early alkaline fluid temperature is in 50-80°C, the first stage of acidic fluid were organic acid that rooted in source rock with over hydrocarbon generation thresholds, and the temperature is between 80-105°C. With the increase of buried depth, the second stage of alkaline appeared in the temperature between 95-120°C, meanwhile the organic acid was consumed. As a large scale hydrocarbon matured and released more  $CO_2$ , the second stage of acidic fluid

appeared in 110-140°C. However, it is hard to finding obvious corrosion phenomenon because of the acidic fluid were used out quickly, then the diagenetic environment return to the alkaline finally and until now (Dai Zhiping, et al., 2013). Using the statistics of homogenization temperature of hydrocarbon inclusions, the period of hydrocarbon accumulation of the first member of Funing formation( $E_1f_1$ ) were determined, the temperature peak of the first period of hydrocarbon accumulation at about 80°C, while the temperature peak of the second period at about 120°C. Due to the difference of tectonic activities between different basin tectonic belts, the hydrocarbon accumulation occurred during 46-37Ma in the southern fault-step belt, while during 40.9-37.5Ma in the northern slope belt, and their main accumulation is the second time (Li Rufeng, et al., 2010).

## 3 Genetic Types of Oil Pool

Through quantitative statistics of the influence of different diagenesis on reservoir porosity and using the porosity evolution of reservoir in geological period recovery method (Wang Yanzhong, et al., 2013), the tight reservoir petrophysical property evolution of the first member of Funing formation( $E_1f_1$ ) were recovered. Combined with the determination of hydrocarbon accumulation period, It's concluded that the stage of reservoir compacting are after the time of hydrocarbon injection in the southern fault-step belt. Whereas the stage of reservoir compacting are before the time of hydrocarbon injection in the northern slope belt.

## References

- Dai Zhiping, Chen Yong, Yu Wenquan. Evolution of diagenesis environment of the 1st member Funing formation in Gaoyou Sag, evidence from fluid inclusions. *Journal of Shandong University of Science and Technology*, 2013, 32(5): 53-60(in chinese).
- Li Rufeng, Chen Liqiong, Li Yajun, SONG Ning. The thermal history reconstruction and hydrocarbon accumulation period discrimination of Gaoyou Depression in Subei Basin. *Earth Science Frontiers*, 2010, 17(4): 151-159(in chinese).
- Wang Yanzhong, Cao Yingchang, Xi Kelai, Song Guoqi, Liu Huimin. A recovery method for porosity evolution of clastic reservoirs with geological time, a case study from the upper submember of  $Es_4$  in the Dongying depression, Jiyang Subbasin. *Acta Petrolei Sincia*, 2013, 34(6): 1100-1111(in chinese).
- Wu Siyi, Sima, Liqiang, Yuan Long, Wen Xinfang. Characteristics and genesis of low permeability reservoir of the first member of Fuyi Formation in Gaoyou Sag. *Lithologic Reservoirs*, 2014, 26(2): 47-53(in chinese).
- Zhang Jinliang, Liu Baojun, Mao Fengming, Chang Xiangchun. Clastic diagenesis and reservoir characteristics of Funing Formation in north slope of Gaoyou Depression in Subei Basin. *Acta Petrolei Sincia*, 2003, 24(2): 43-49(in chinese).