



# Analysis on the Hydrocarbon Accumulation Conditions and Exploration Potential of Deep Middle-Lower Jurassic Reservoirs in South Turgay Basin

Ming-jun Zhang<sup>1</sup>(✉), Zhao-feng Wang<sup>2</sup>, Ling-hong Kong<sup>1</sup>, Wei Yin<sup>1</sup>, Rui Cai<sup>1</sup>, and Xiao-feng Sheng<sup>1</sup>

<sup>1</sup> Research Institute of Petroleum Exploration and Development, CNPC, Beijing, China

zhangmingjun-hw@petrochina.com.cn

<sup>2</sup> China Oil International PK Limited Liability Company, Beijing, China

**Abstract.** According to comprehensive researches on the structure, source rock, accumulating conditions and exploration potential, the accumulating conditions are relatively good in the Middle-Lower Jurassic formations where the source rock has reached the maturity threshold at 2200 m, and as the primary source rocks, J1 and J2ds are thick and widely distributed, but the J2kr source rock reached the maturity threshold locally in the center of the sag in the South Turgay Basin. Various fans at the sag slope can serve as good reservoirs, which is favorable to develop lithologic traps. In addition, in the Middle-Lower Jurassic corresponding to the basin rifting, complicated fault systems were developed with a lot of faulted blocks and faulted noses which are favorable for hydrocarbon accumulation. For the deep J12, on the basis of geologic analysis and in combination with the hydrocarbon migration and accumulation system, the paper points out three prospective slope zones, and each of which is further divided into three structural belts: high fault step, central fault step and low fault step, and the central fault step contains the best lithologic and lithologic – structural hydrocarbon accumulation belts.

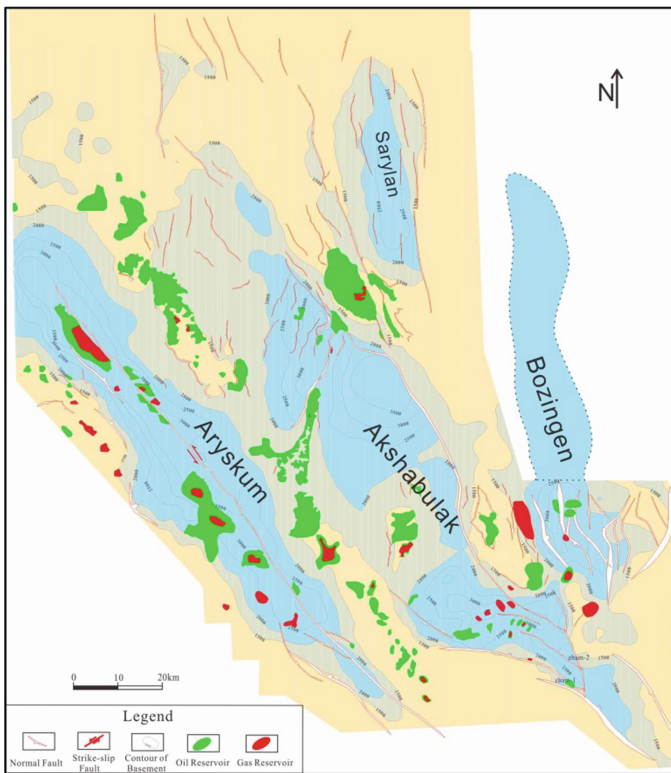
**Keywords:** South Turgay Basin · Deep Middle-Lower Jurassic formation · Accumulation condition · Hydrocarbon accumulation belt

## 1 Introduction

Located in Middle Kazakhstan, the South Turgay Basin is a Mesozoic rift basin covering about  $8 \times 10^4$  km<sup>2</sup>. The exploration in this basin was initiated at the end of the 1960s [1], and after more than five decades, the basin has been explored extensively and highly, and almost all shallow traps have been drilled. In order to get new hydrocarbon discoveries, the exploration must transfer to the Middle-Lower Jurassic formations while continuing precise rollover exploration around the discovered oilfields.

## 2 Geological Conditions

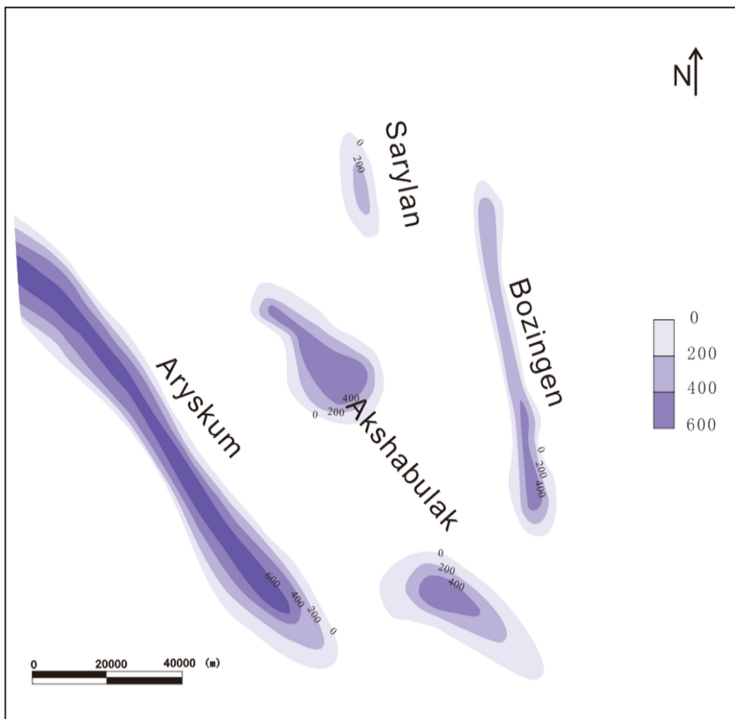
The South Turgay basin is a Mesozoic terrestrial rift basin with alternative horsts and grabens. In this basin, the depositional section is mainly the J-K lacustrine sandy mudstone [2]; the Middle-Lower Jurassic lacustrine mudstone is source rock; three accumulation assemblages: Jurassic, J12 and J3-K1, are developed; and the discovered oilfields are mainly distributed on the bulge and later inverted structure in the sag (see Fig. 1). The exploration in this basin was initiated at the end of the 1960s. In 1984 the biggest oilfield, Kumkol, was discovered with the cumulative oil reserves more than  $6 \times 10^8$  tons. After more than five decades, the exploration has been conducted extensively and highly, and almost all the shallow traps were drilled. In order to get new hydrocarbon discoveries in this basin, the exploration emphasis must transfer to the Middle-Lower Jurassic while continuing precise rollover exploration around the discovered oilfields [3]. In the past two years, PetroChina made preliminary breakthrough to the deep J12 that was deemed as the future exploration target with complicated faulted blocks and lithologic traps. This study investigates the sag slope to clarify the potential hydrocarbon accumulation belt and provide technical basis for future deployment.



**Fig. 1.** Hydrocarbon distribution in South Turgay Basin

### 3 Source Rock Evaluation

The effective source rocks in the South Turgay Basin are mainly the J1, J2ds and J2kr of deep and half-deep lacustrine facies sedimented during the rifting stage, which are generally taken as one petroleum system in the basin. On the basis of sedimentary facies and drilling data, the plotted contours (see Fig. 2) of effective source rocks show that the distribution of the source rocks in various sags in the basin is greatly different, such as the vertical distribution [4]. Generally, the source rock is very thick in the Lower Jurassic J1, intermediate in the Middle Jurassic J2ds, and thin in the Middle Jurassic J2kr. The Aryskum sag contains the thickest and widest spread effective source rock, the Akshabulak and Bozingen sags are the second, with a limited range, and the Sarylan sag is the poorest.



**Fig. 2.** Effective source rock contours of J1

The J1 in the South Turgay Basin is a section of source rock making the greatest contribution to the hydrocarbon accumulation. On the distribution map, it amounts to 600 m thick in the Aryskum sag and spreads in a wide range, 400 m thick in the Akshabulak sag, up to 400 m thick in the south of the Bozingen sag, and only 200 m in the Sarylan sag. At present, the J1 acts as the major targets for deep exploration, thus the Aryskum and Akshabulak sags should be highlighted with consideration of effective source rock distribution.

### 4 Depositional Characteristics and Favorable Belt Prediction

The J12 was developed in the basin rifting stage when the sags were isolated, and the strong tectonic movement created the complicated fault system in the southeastern area [5]. Combined with the drilling, seismic and laboratory data, the J12 was divided into five 3rd sequences and ten 4th sequences (see Fig. 3), and the chronostratigraphic framework was constructed within the basin range. Generally in the J12, the rock is coarse at the bottom, mainly medium to coarse sandstone (locally with pebbles), and then fine rock upward, fan delta at the steep slope and delta at the gentle slope. In the early J1 stage, the deposit was mainly of fan delta facies (see Fig. 4), and the J2ds was developed in the maximum flooding within the basin range, with mudstone. In the J2kr stage, the deposit was mainly of massive delta facies, and fan delta facies was developed perpendicular to the short axis at the sag slope. This section is expected to have accumulating conditions for lithologic and lithologic - structural traps according to structural interpretation.

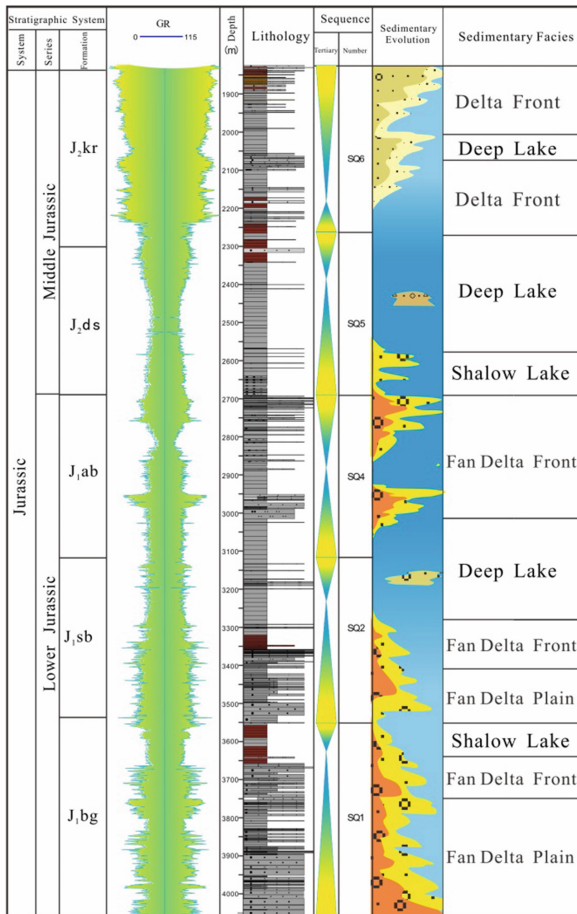
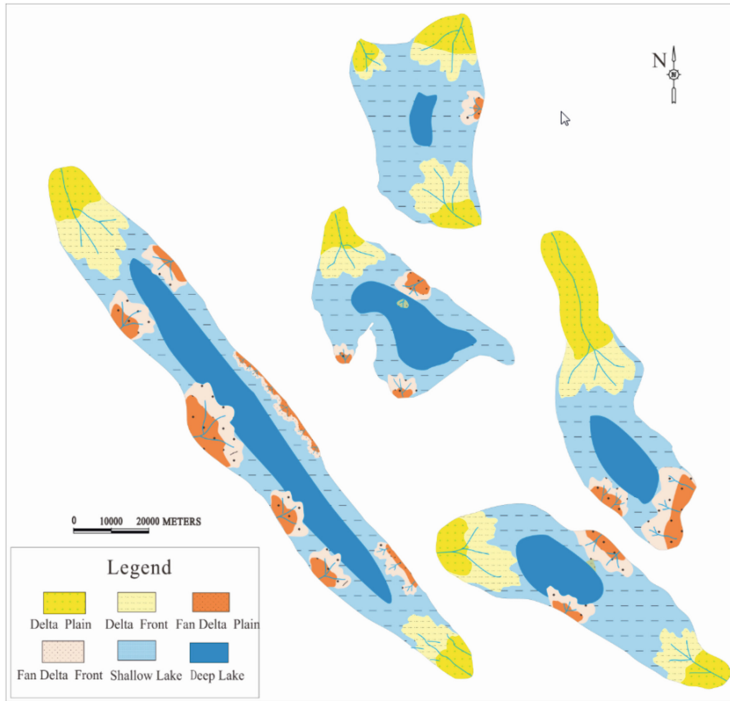
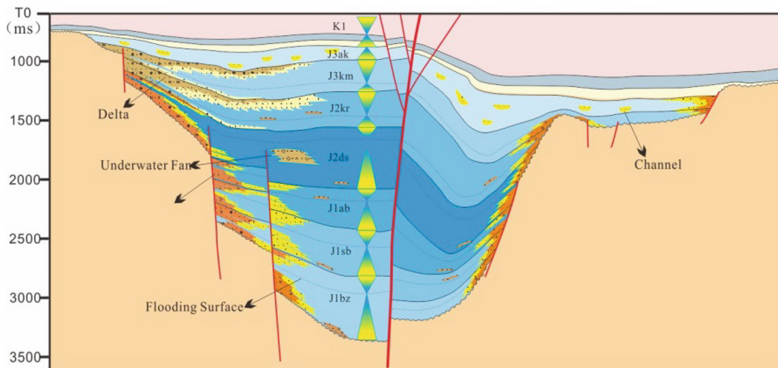


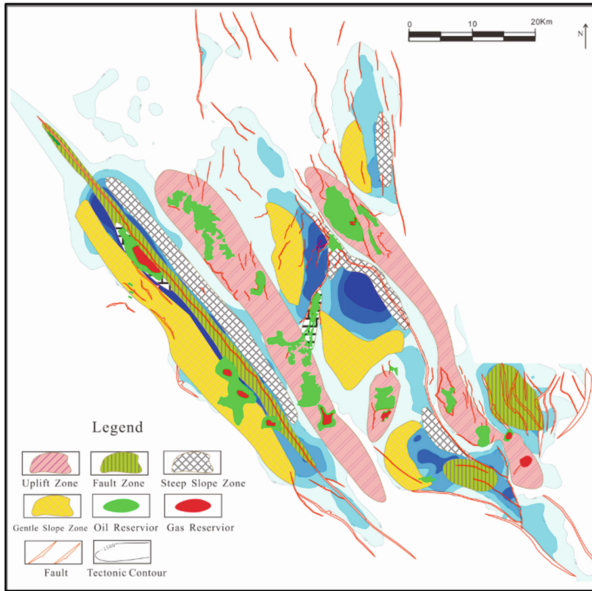
Fig. 3. Sequence and composite depositional analysis of the Middle-Lower Jurassic



**Fig. 4.** Sedimentary facies map of J1ab formation



**Fig. 5.** Sequence stratigraphic filling pattern of Aryskum sag in South Turgay Basin (E-W trending)



**Fig. 6.** Structural belt division in South Turgay Basin

According to the sequence stratigraphic development and evolution as well as the type and distribution of the sedimentary facies of each sequence, in combination with the reservoir development and adjacent oil gas discoveries etc., analysis was conducted on the prospective Middle-Lower Jurassic lithologic-stratigraphic traps in the northern South Turgay Basin, by taking the relation between the reservoir and fault break and palaeo-geomorphology into account. Considering the hydrocarbon accumulating system, the exploration potential in the Middle-Lower Jurassic in the South Turgay Basin is believed in two domains, lithologic traps and complicated faulted block traps. In the Aryskum and Akashabulak sags, the Middle-Lower Jurassic present good geologic conditions for lithologic-stratigraphic reservoirs. In the Aryskum sag, the west slope has the most prospective lithologic traps and three structural belts: high fault step, central fault step and low fault step (see Fig. 5). In the central fault step, faults are developed, physical properties are preferably good, the sandstone-to-formation ratio is 0.3 to 0.4 at the fan front, and close to the oil source, the most prospective lithologic and lithologic - structural traps are developed [6]. The sandstone in the Aybolin Fm. and Doshan Fm. (underwater fan channel, coastal lacustrine sand bar and delta front) are well developed and controlled by the slope break, and laterally approaches or alternates with the source rock at the sag center, which provides good conditions for lithologic and lithologic - structural reservoirs. The fan delta sandstone at the northern slope of the Akshabulak sag and the western slope of the Bozington sag might also develop prospective lithologic traps (see Fig. 6).

In addition, the south end of the Akshabulak sag developed complicated faulted blocks in the Middle-Lower Jurassic, and the formation itself acts as the major source

rock that supplies rich oil source. As long as the faulted block trap is available, hydrocarbon will accumulate in the trap.

### 5 Exploration Case

With the technical methods of fine seismic interpretation, reservoir inversion and hydrocarbon detection etc., based on the extensive researches into the accumulating conditions and comprehensive geology, Well K-18 (see Figs. 7 and 8) was drilled into the J2ds sandstone in the central fault step of the west slope in the Aryskum sag. The target layer was found with good hydrocarbon shows, logging interpretation proved a pay zone about 30 m thick, and well test showed a high pressure condensate gas pool with very high production.

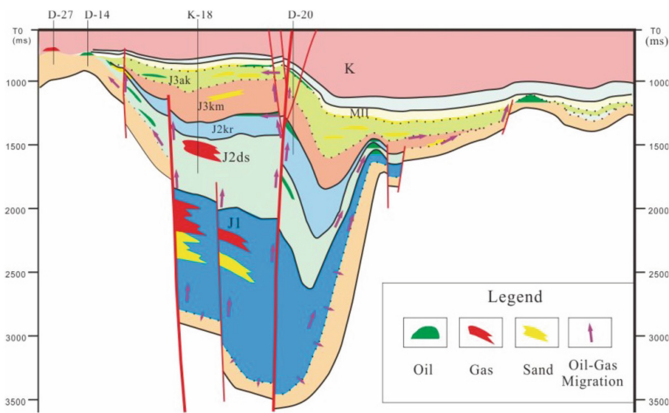


Fig. 7. Accumulation pattern for Aryskum sag in the South Turgay Basin (E-W trending)

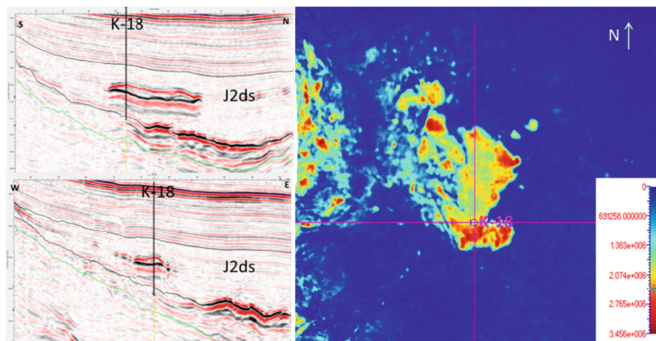


Fig. 8. Seismic sections across well K-18 and RMS amplitude of J2ds

## 6 Conclusions

Extensive exploration has been carried out in the South Turgay Basin where shallow targets were almost drilled. According to resource prediction, future potential is mainly concentrated on the J12. The J12 itself is the major source rock in this basin and reached the mature threshold at about 2200 m, where various fans developed at the slope can serve as good reservoirs to form lithologic traps. What's more, the Middle-Lower Jurassic corresponding to the fault rifting stage resulted in complicated fault systems associated with a lot of faulted blocks and faulted noses which facilitate hydrocarbon accumulation. The favorable slope zone can be divided into three structural belts: high fault step, central fault step, low fault step. The central fault step developed the best lithologic and lithologic - structural accumulations. Drilling activities in the Arysium sag show the deep J12 formation presents a bright exploration future.

**Acknowledgments.** The project is supported by the “Special and Significant Project of National Science and Technology: Global oil and gas resources assessment and constituencies with research” and CNPC project (Numbers are 2016ZX05029-005 and 2016D-4301).

## References

1. Wu, Y., Sun, C., Wang, D., et al.: Hydrocarbon distribution characteristics and main controlling factors of accumulation in South Konys Oilfield in South Turgay Basin, Kazakhstan. *Nat. Gas Geosci.* **27**(11), 2013–2022 (2016)
2. Dai, H., Hong, L., Zhang, M., et al.: The prospect for oil-gas exploration of Doshan carbonate buried hill in South Turgai Basin. *Xinjiang Geol.* **31**(4), 334–338 (2013)
3. Zhang, C., Chen, A., Pu, Y., et al.: The Arysium depression tectonic dynamics analysis of South Turgay Basin. *Xinjiang Pet. Geol.* **33**(1), 127–129 (2012)
4. Wang, G., Xu, F., Chen, X., et al.: Strike slip faults reversion and deep geologic setting in north Qaidam Basin. *Pet. Explor. Dev.* **33**(2), 201–204 (2006)
5. Wu, L., Li, X., Wang, C., et al.: Origin of crude oil and relation with hydrocarbon migration and accumulation in South Turgai Basin. *Xinjiang Pet. Geol.* **33**(4), 509–512 (2012)
6. Kong, X., Yin, J., et al.: Oil-gas geological features and its exploration potential in South Turgai Basin. *Kazakhstan. Lithol. Reserv.* **19**(3), 48–53 (2007)