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Control of oil and gas formation in the Shahejie Formation by the Li Xian Slope Fracture in the Jizhong Depression

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Abstract: Combining the information on the period of fault activity, hydrocarbon source rock distribution and reservoir distribution within the Lixian slope of the Jizhong Depression, the study was conducted on the controlling role of fractures on hydrocarbon formation. The results of the study show that: 1. the influence of fractures on the formation of traps, (1) the nose-like tectonic zone controls the formation of lithological traps of broken nose traps; (2) traps are formed at the segmentation point of the lower plate of the positive fault Gao Yang fault, which is located at the boundary of the external and external zones; (3) Fault activity controls the formation of trap closure; 2. The influence of fracture on oil and gas transportation, the role of oil and gas in the process of vertical transportation, combined with the location of hydrocarbon source rock development and the activity of the fault, fracture controls the vertical transportation of oil and gas.

Keywords: Lixian slope; Hydrocarbon source rock distribution; Oil and gas reservoir formation; Oil and gas transportation; Confinement.

1. Introduction

Fractures with complex orientation are usually important for the study of the regional characteristics of basins during the formation of basins, affecting the development of basin boundaries and thus the overall structural evolution pattern of the whole basin, as well as the hydrocarbon distribution patterns and their enrichment in small study areas [1]. As the exploration practice in major basins continues to advance, folds and joints developed in the interior of terrestrial basins have a certain influence on hydrocarbon transport and reservoir formation, while the influence of fractures on hydrocarbon transport and reservoir formation is more obvious than that of fractures, so the importance of fractures on hydrocarbon transport and reservoir formation is gaining attention. In basins with different types of sedimentation, there are differences in the form of structural characteristics and therefore in the pooling of hydrocarbons, and the types of hydrocarbon reservoirs developed are also very different. As a result of tectonic movements, the activity of fractures is characterized by universality, periodicity, differences, stages, inheritance and specificity, which determines that fractures are inextricably linked to the formation and distribution of hydrocarbon reservoirs in the formation [2]. The development of fractures and the influence of multi-phase stress lay the boundary conditions and geological foundation for the composition of basin formations, the maturity of hydrocarbon source rocks and hydrocarbon production processes, the enrichment of hydrocarbons, and the development characteristics of traps; the control of fractures on the formation and development of basins is an important manifestation of fractures on hydrocarbon transport and accumulation, and the difference of fracture activity can provide channels for hydrocarbon transport and control the development of different types of traps. The difference in fracture activity can provide channels for hydrocarbon transport and control the development of different types of traps, which ultimately restricts the spatial distribution pattern of hydrocarbon deposits.

The hydrocarbon transport pathway is the pivot that combines both hydrocarbon source formation and trap together. The results of hydrocarbon exploration in major oil fields around the world show that fractures are not necessary for the formation of hydrocarbon reservoirs, and that reservoirs can still be formed even without the influence of fractures. Such reservoirs are developed in marine sedimentary basins, but in terrestrial basins, the influence caused by complex faults becomes the main controlling element of various geological activities, which in turn plays the main function of controlling transport and reservoir. Regarding the importance of fractures in controlling hydrocarbon transport and reservoir formation, domestic and foreign scholars have formed the following four general statements [3-6]: 1. fractures are channels for hydrocarbon transport; 2. fractures block hydrocarbon transport and thus reservoir formation; 3. fractures neither exist as hydrocarbon channels nor play a role in blocking hydrocarbon transport. They believe that the blocking effect of faults is mainly determined by the lithological contact relationship between the upper and lower plates of faults and different stratigraphic types; 4. Fractures play the role of both transport channels and blocking effects, and many typical oil and gas reservoirs in oil and gas fields support these views from the geological point of view.

At present, most experts at home and abroad agree that faults can be both a transport pathway for oil and gas and play a blocking role for oil and gas transport, with obvious two-sidedness. Depending on the location of the fault and the period of activity, when the fault is active, it has a certain transmission effect on the vertical and lateral transport of hydrocarbons, and when the other part of the fault ceases to be active, it will play a blocking effect on the transport of hydrocarbons and thus the formation of hydrocarbons [7-13].

Rao Yang Depression has complex geological conditions and various types of oil and gas reservoirs, mainly including lithologic reservoirs, tectonic reservoirs, stratigraphic

reservoirs and composite reservoirs. Among them, tectonic reservoir is the most important type of reservoir in the Paleocene system. (Figure 1). For tectonic reservoirs, fractures play a vital role in the whole reservoir formation process, so this paper will study the role of fractures in controlling the trap and transport during the formation process of oil and gas in the Lixian slope.

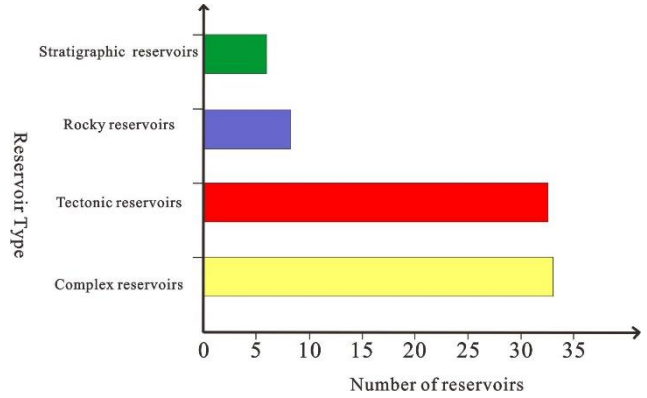


Fig.1 Map of the number of reservoir types on the slopes of Li Xian

2. Effective hydrocarbon source rock distribution

The hydrocarbon source rocks of the Es1 section of the Li Xian slope are widely developed in the Rao Yang depression. In addition to the development in the Renxi and Suning depressional belts, they are also present in the north-central west of the Li County slope, crossing the Gaoyang fault to the west and extending as far as the Baoding depression and as far as the Shenze low relief to the south. In this study, the TOC values of the existing mudstones were calculated, and the results show that the oblique high-quality mudstones are mainly developed in the inner-middle zone of the slope (TOC values can reach more than 2.5%), and the high-efficiency source rocks are mainly distributed in the depressional trough zone and the inner-middle zone of the Li County slope, as well as the Baobei depressional trough zone (Figure 2).

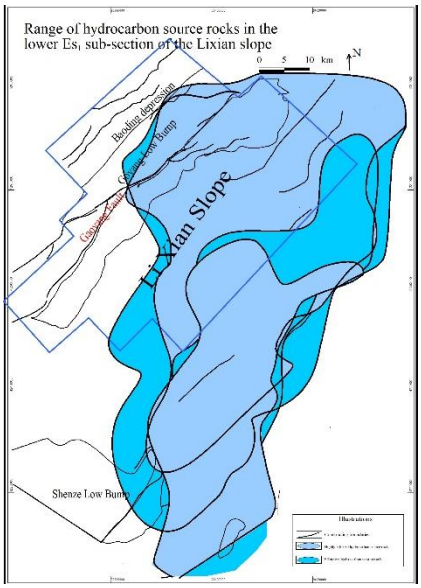


Fig.2 Range of hydrocarbon source rocks in the lower sub-section of Es1 on the Li Xian slope



Fig.3 Range of hydrocarbon source rocks in the upper Es3 sub-section of the Lixian slope

The range of hydrocarbon source rocks in the upper sub-section of Es3 is smaller than the range of source rocks in the lower section of Es1, mainly distributed in the Masi depression, the Suning depression and the area from Dawangzhuang to Liuchu to the south. Compared with the Shaxia subsegment source, the Sha San Shang hydrocarbon source rocks are not developed in the Li County slope, and the efficient source rocks are concentrated in the southern part of the Suning depression in the inner belt of the Li County slope, and the effective hydrocarbon source rock range includes the Suning depression and the Masi depression area (Figure 5).

3. The role of fracture in the control of ring closure

Lithologic traps and tectonic traps are mainly developed on the slopes of Li Xian, among which lithologic traps are mainly developed on the inner and middle zones of the slopes of Li Xian. Compared with lithologic traps, tectonic traps are more widely developed on the slopes of Li Xian and are the main traps of the slopes of Li Xian, including nose-like tectonic traps on the inner and middle zones, traps controlled by the segmentation of the Gao Yang fault on the reverse fault on the middle zone, and traps controlled by the fault activity on the outer zone of Li Xian.

1)Fault-controlled nose-like tectonic trap

Five nose-like tectonic zones have been developed in the inner zone of the Li Xian slope from north to south. Under the influence of regional induced tension and differential compaction, the early fault development caused the stratigraphic development of the lift-slope block, resulting in the ancient uplift, and then the stratigraphic overlay on the early ancient uplift, resulting in the formation of the nasal tectonic zone (Figure 4); another type of nasal tectonic zone is formed by the segmental growth of the control slope fault (Figure 6). The segmentation points of the Liuchu and Renqiu faults correspond to the Li Xian South nasal tectonic zone and the Gaoyang nasal tectonic zone, respectively (Figure 4, Figure 5), and when the control slope fault grows in segments, it is located at the segmentation points and shows uplift in the profile, so the subsequent strata are deposited and form the nasal tectonic zone.

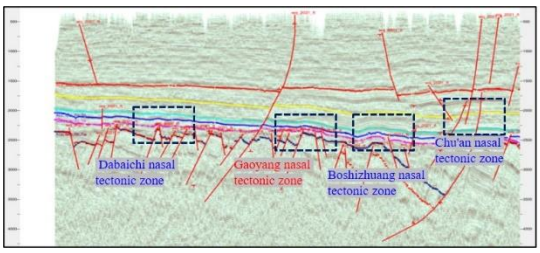


Fig.4 Fault combination pattern of the Chu'an nasal tectonic zone, Boshizhuang nasal tectonic zone, Gaoyang nasal tectonic zone and Dabaichi nasal tectonic zone section

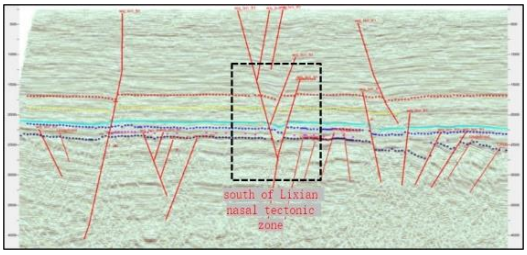


Fig.5 Fault combination pattern of the south of Lixian nasal tectonic zone

These NW oriented nose-like zones are cut by NE oriented faults, which in turn form broken nose-like traps, and the upward dipping sharp extinction type lithological traps can be formed in the wings of the nose-like structures. The segmental growth of the faults and the early fault development lead to the lifting of the strata to produce ancient uplift to control the formation of the nasal formation, which in turn controls the formation of the broken nose trap and the lithologic trap of the flank, and in this process, the faults indirectly control the formation of the trap.

2) Reverse fault control circle

The Gao Yang fault is located at the junction of the middle zone of the outer belt of the Li Xian slope, and the Gao Yang fault is a reverse positive fault with obvious segmental growth characteristics, the reservoir sand body of the lower disk of the reverse fault is developed in the slope area, and the buckling block formed under the role of the reverse fault at the location of the maximum fault distance in the lower disk of the reverse fault is obscured by the fault to form the reverse fault trap, the fault trap formed by the isolated growth of the reverse fault is developed at the location of the maximum fault distance in the lower disk of the fault, and the fault trap formed by the segmental growth of the reverse fault is developed at the location of the maximum fault distance in the lower disk of each fault section, so the trap is developed between two adjacent segmental points in the lower disk of the reverse fault (Figure 6).

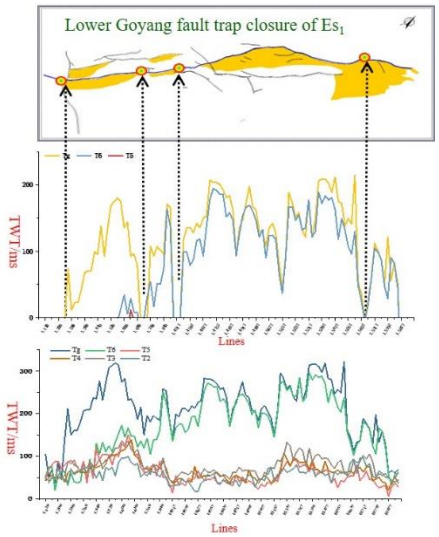


Fig.6 Fault distance-distance curve and back stripping results of the Goyang fault

3) Fault activity control circle

According to the activity of the faults and the configuration relationship with hydrocarbon source rocks and reservoirs, the faults in the outer zone are divided into oil source faults, blocking faults and transmission faults. The faults located outside the range of hydrocarbon source rocks and with large scale and strong activity in the late stage are transmission faults, which provide a channel for oil and gas formation (Figure 7).

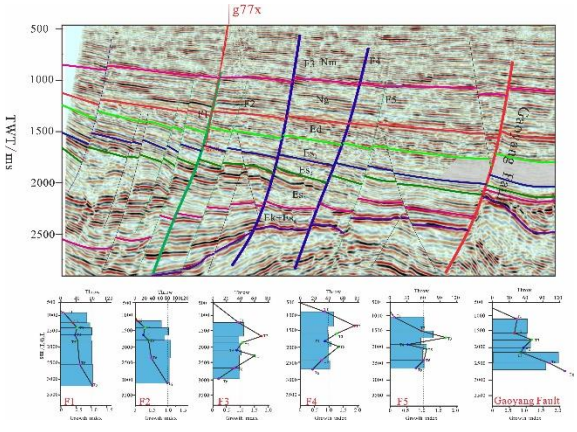


Fig.7 Typical section and fault activity in the outer zone of Li Xian

4. The role of fracture in controlling oil and gas transport

The controlling role of fractures in the slope area on the vertical transmission and transport of oil and gas requires consideration of the growth and evolution process of fractures, the active period of fractures, and the differentiation of different types of fractures of different grades, and on this basis, the role of three types of reservoir-controlling fractures in the formation of oil and gas is analyzed in a targeted manner in combination with the anatomy of oil and gas reservoirs, which are the vertical transmission and transport role of oil and gas source fractures, the lateral closure ability of blocking fractures, and the adjustment of fractures on the cover The role of fractures in reservoir formation is the vertical transport of oil and gas source fractures, the lateral sealing ability of blocking fractures, and the adjustment of fractures to the cover layer.

For oil and gas transport in slope areas, the role of

adjustment fractures in the process of oil and gas transport and accumulation and reservoir formation is crucial. The ability of adjusting fractures to adjust hydrocarbons vertically mainly depends on their damage to the cover, and a high degree of damage results in a higher number of hydrocarbons adjusted vertically.

Combining the kinematic characteristics of the fractures and the period of hydrocarbon formation, the matching relationship between the fracture system and hydrocarbon transport in the study area can be determined. The Lixian slope is formed at the end of the Ed and the the Nm, and the fractures active during the deposition of the Ed (middle) and the Nm (late) can be used as the transmission faults for the vertical adjustment of hydrocarbons, among which the faults that can communicate with hydrocarbon source rocks and reservoirs can be regarded as both oil source fractures. Obstruction faults are those that are inactive during the critical period of reservoir formation. Based on the results of the fracture system, the development and distribution of the transmission faults, oil source faults and blocking faults can be determined.

Based on the geological background of the two phases of reservoir formation in the Lixian slope, Es1 and Es3 are the two sets of strata that develop hydrocarbon source rocks. Combining the types of the divided fracture system, the ensemble of Es1 and Es3 hydrocarbon source rocks is taken as the hydrocarbon source rock range, and the Lixian slope is divided into the oil source faults that communicate hydrocarbon source rocks and reservoir-forming strata (Ed and Nm) located in the hydrocarbon source rock range, and the oil source faults located outside the source The distribution of oil source faults at the T3 and T4 reflection interfaces was determined on the basis of these faults (Figure 8 and Figure 9).

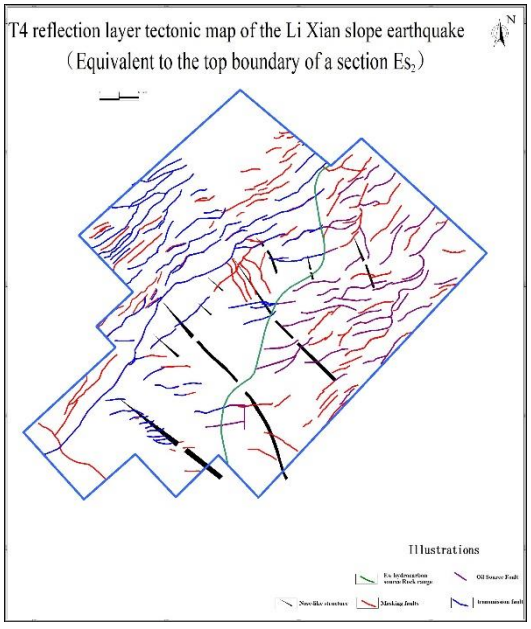


Fig.8 Distribution of oil source-transmission fracture plan at T4 interface

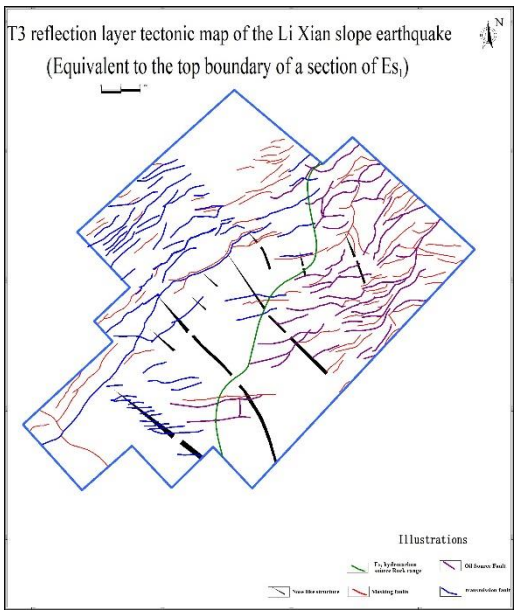


Fig.9 Distribution of oil source-transmission fracture plan at T3 interface

5. Conclusion

The faults play an important role in the formation of traps on the slopes of Lixian: (1) five nose-like tectonic zones distributed from north to south control the formation of traps; (2) the directional positive faults located at the boundary of the middle and outer zones form traps at the segmentation point of the lower plate of the Gaoyang fault; (3) the activity of the faults control the formation of traps, and these faults are weaker or cease to be active in the late period, i.e., during the period of Tantao Minghua Town, and when the oil and gas of the Tantao Dongying Formation is transported to this area, the oil and gas will gather here to form a typical fault trap. When this type of fault is encountered, oil and gas will gather here and form a typical faulted trap.

Fault plays an important role in the transport of oil and gas, and the role of fracture in the vertical transport of oil and gas, according to the relationship between the activity of faults and hydrocarbon source rocks and the configuration of reservoir formation period, the faults are divided into oil source faults, transmission faults and blocking faults to control the vertical transport of oil and gas.

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