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The tectonic evolution and accumulation controlling characteristics of the middle fault depress belt of Hailaer-Tamtsag basin

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Abstract

The oil and gas resources is rich in the middle fault depress belt of Hailaer-Tamtsag basin. In recent years, gradually exploration success shows that the exploration potential of structural belt. But under the control of the complex tectonic and sedimentary evolution ,hydrocarbon accumulation and distribution regularity needs further research. Using simulation of balance section the middle fault depress belt, combined with filling characteristics and superposition characteristics of basin that makes clear about the middle fault depress belt evolution process and the structural of rich oil forming process in the different tectonic evolution stages, and its control action of hydrocarbon accumulation. The study shows that the Hailaer-Tamtsag basin be made up with residual basin (under Tongbomiao Formation) and passive rift basin (Nantun formation—the late of Qinyuangang formation), superposition of two different nature of the basin. In this paper, we further be divided the passive rift basin into four evolution stages:Lower member of Nantun 1 formation—member of Nantun 1 formation, initial weak fault depression period; upper member of Nantun 1 formation—Nantun 2 formation, strongly fault depression period; Damoguaihe formation — Yimin formation, fault depression-depression transformation period; Qinyuangang formation—Now, depression period；
Complex tectonic evolution process controling the three types of oil and gas

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accumulation zone development of the middle fault depress belt: overturned structure belt、central anticlinal belt or central uplift belt and tilted uplift belt; Inversion structure belt controls the upper oil gas bearing system, formation of the fault depression-depression transformation period. Central anticlinal belt or central uplift belt controls the middle oil gas bearing system, formation of the strongly fault depression period. Tilted uplift belt controls the lower oil gas bearing system, formation of the initial weak faulted period.

Key words: Hailaer-Tamtsag basin; middle fault depress belt; tectonic evolution; accumulation controlling characteristics

0. INTRODUCTION

Hailar-Tamsag basin is composed of small faulted lake basins and it's a part of the rift system in northeast Asia during the late Mesozoic period, distributed throughout the whole northeast Asian region[1]. The basin is located above the centra asia-ancient aulacogen , bounded by the Derbugan fault, and has unique structural characteristics [2]. Hailar-Tamsag basin as a faulted lake basin in the Cenozoic is one of the oil and gas resources are relatively abundant basin. On the whole, it has tectonic framework that " called E-W zonation and N-S blocking respectively ". The basin is composed of fault depression groups, and the tectonic pattern on the plane can be divided into three fault depression belts and two uplift belts (Fig.1). The central fault depression zone of Hailar-Tamsag basin is rich in oil and gas resources, which is composed of Wuerxun sag, Beier sag, Nanbeier sag, Tanan sag, Dongming sag, Hongqi sag and Hallrhund sag. Basin evolution is affected by multi-stage tectonic movement, and its unique sedimentary and structural evolution features have attracted the attention of many geologists. Predecessors have also done a lot of research work on the unique evolutionary characteristics of Hailar-Tamsag basin [3-5]. However, few studies have been made on the structural evolution characteristics of the central faulted zone in Hailar-Tamsag basin. The central faulted zone is the most important oil-gas-rich zone in the basin. A correct understanding of the structural evolution stage of the central faulted zone is of great significance to the study of the complex accumulation and distribution of oil and gas in the central faulted zone.

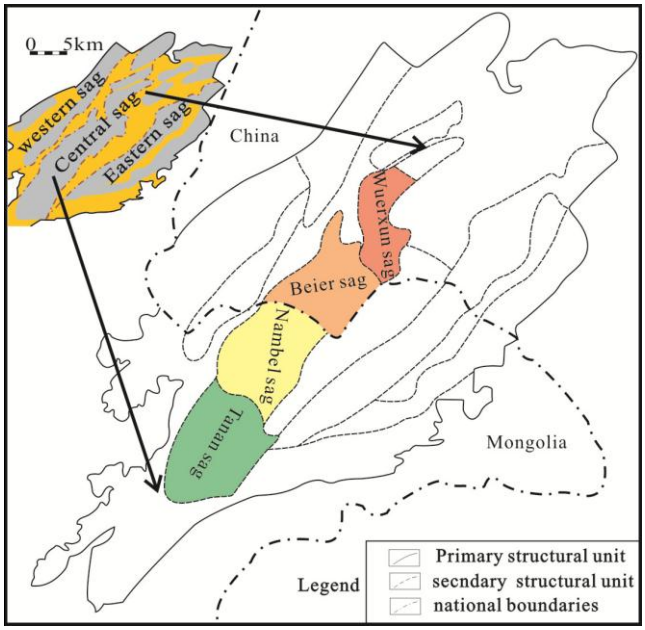

Fig.1 Division of tectonic units in the Hailaer-Tamtsag basin

1.Division of the structural evolution stages of central rift zone in the Hailaer-Tamtsag basin

Basin tectonic evolution is episodic, and each phase of tectonic activity deposits a unique set of stratigraphic sequences. In order to restoration of tectonic evolution process, it is necessary to divide and describe the stratigraphic sequence accurately [6-12]. The main strata developed in the Hailaer-Tamtsag basin include the basement strata of the prepaleozoic and Paleozoic, the strata of Jurassic and cretaceous and above are used as sedimentary covers, which are sedimentary covers with a thickness of about 6000 meters. The strata developed from bottom to top in the central rift zone of Hailaer-Tamtsag basin are: Tongbomiao formation (K_1t), Nantun formation (K_1n), Damoguaihe formation (K_1d), Yimin formation (K_1y) and Qingyuangang formation (K_2q). Through structural evolution recovery combined with the analysis of previous research data, the basin has mainly experienced the evolution stages of intermountain residual basin and passive rift basin in different periods:The sedimentary period of the Tongbomiao formation is in the intermountain residual basin stage; the sedimentary period of the strata from Nantun formation to Qingyuangang formation is in the evolutionary stage of the passive rift basin, among which the passive rift basin can be divided into four evolutionary periods: initial weak fault depression period, strong fault depression period, fault depression-depression transformation period and depression period (Fig.2).

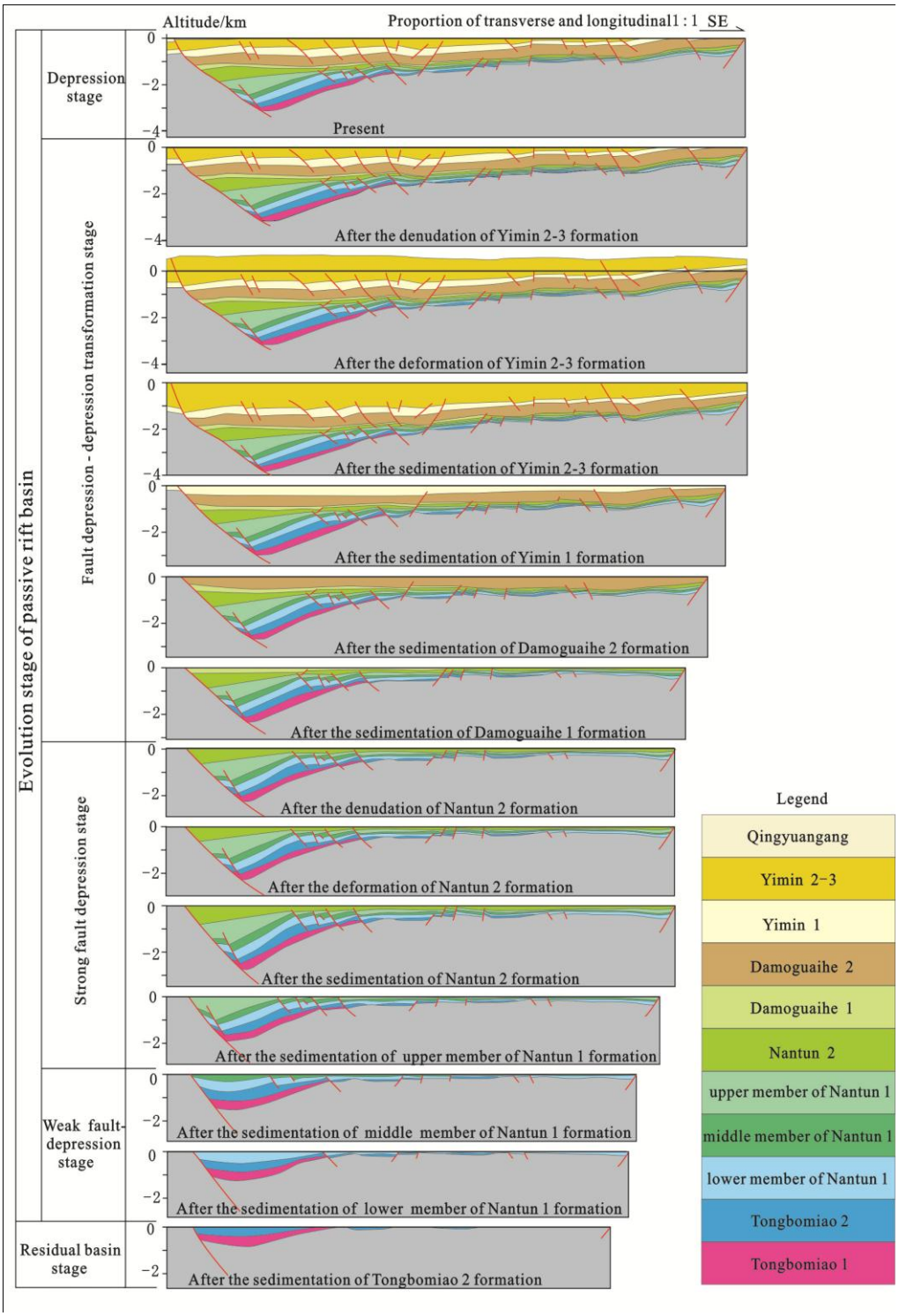

Fig.2 Tectonic evolution sections of the line2787 in the Nanbeier depression

2.The relationship between structural evolution characteristics and hydrocarbon distribution

Through sorting out the tectonic evolution stage of central faulted belt in Hailar-Tamsag basin, three oil-bearing systems are developed in the evolution stage of passive lacunae of the basin[13], because the central fault belt is a complex structure makes the different distributions of petroleum system evolution process of different structural belt, fault belt in central including three kinds of rich oil and gas accumulation zones: tilted uplift belt, central uplift, or the central anticline belt and tectonic inversion belt .

1. Configuration of residual paleo-uplift and uplift belt in T3 reflector controlled the hydrocarbon distribution

In the initial rifting stage, the sedimentary strata are dominated by sand and mud interbeds, which are affected by the paleogeomorphology of the residual basin. The main source rocks of the Hai-ta (Hailar-Tamsag) basin are located in the Nantun formation, and the best source rocks are the middle member of Nantun 1 formation, which is not very thick but has excellent hydrocarbon generation ability. The sedimentary mud-rich strata in the middle member of Nantun 1 formation provide a material basis for the formation of hydrocarbon source rocks. Judging from the residual ancient uplifts of T3 reflector, these ancient uplifts have the characteristics of inheritance development during the sedimentary process of passive rifting, and become the favorable location for hydrocarbon accumulation in the passive rifting strata. In addition, in the process of stratigraphic deposition in the passive rifting period, a large number of reverse faults were formed along with two weak tectonic deformations, and its footwall uplift also became a favorable location for oil and gas accumulation.

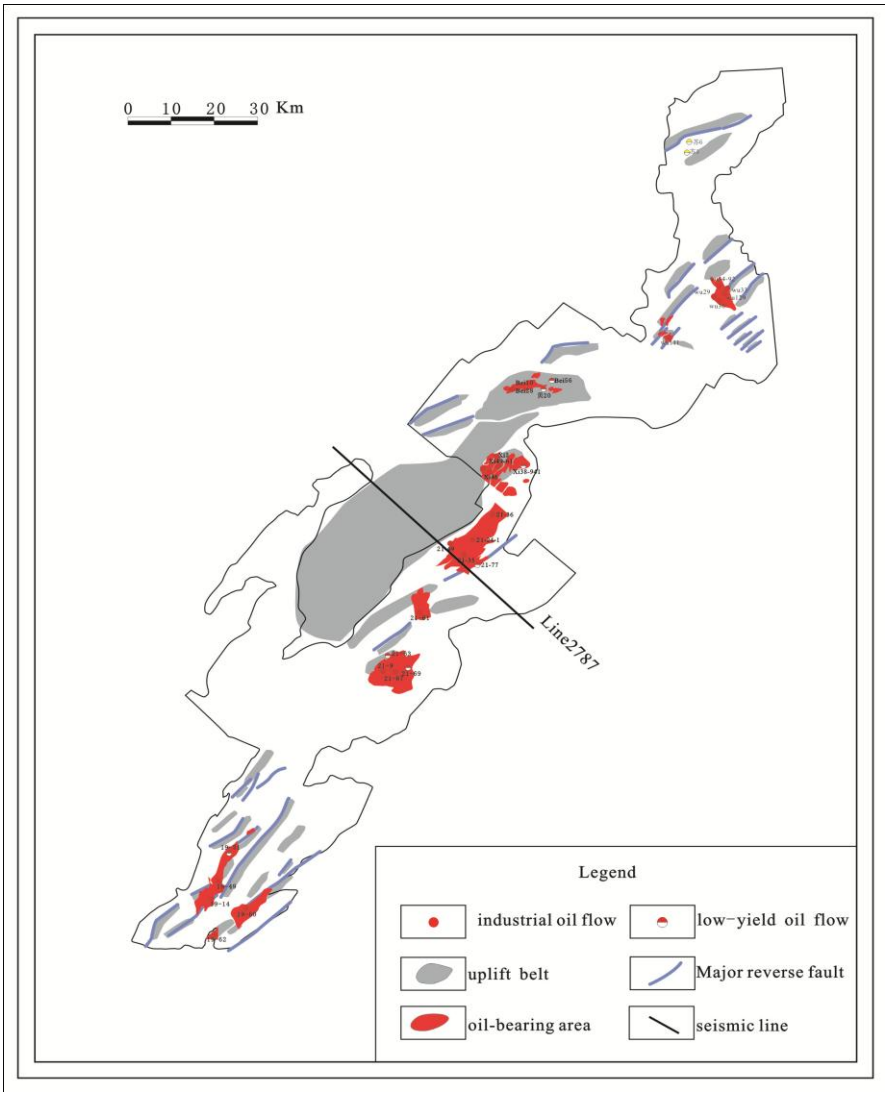

Fig.3 Congruent map of the T3 layer's paleo uplift and T_3-T_{23-2} layer's hydrocarbon distribution of the Hailaer-Tamtsag basin

According to the research results (Fig. 3), the distribution of hydrocarbon in the passive rifting period is mostly related to the T3 paleo-uplift and the local unconformity formed by three weak transformations. A large number of reverse faults were formed at the end of the sedimentation of the strata in the south section of the middle section under NE shear strike-slip stress, and at the same time, the footwall of the reverse fault formed a lift uplift, which was blocked by the reverse fault and thus formed a reverse fault block trap. This reverse fault-controlled block trap is the main type of hydrocarbon accumulation trap in the fault depression zone in the middle of the Hai-ta basin, which serves as the lower hydrocarbon bearing system.

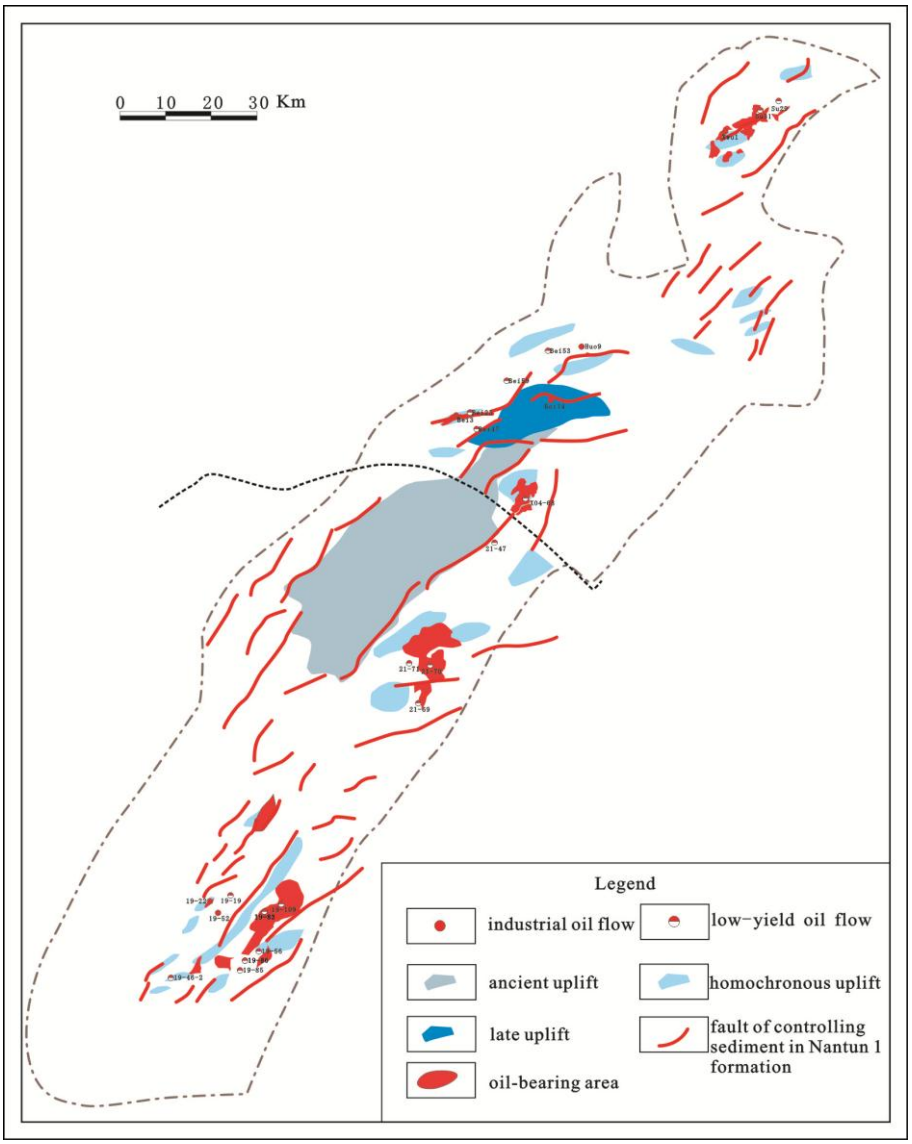

Fig.4 Congruent map of the T_{22} layer's paleo uplift and $T_{23\text{-}1}$-T_{23} layer's hydrocarbon distribution of the Hailaer-Tamtsag basin

2. Inherits the ancient uplift, uplift and new central anticline in the T22 reflector indicates the hydrocarbon distribution in the Nantun 1 formation and part of Nantun 2 formation

The strong rifting stage is the sedimentary period of the upper member of the Nantun 1 formation and the Nantun 2 formation. The late sedimentary period of the Nantun 2 formation is the strong reconstruction period of the central fault depression zone with strong tectonic activity. The intensity of rifting is the highest at the end of the

sedimentary period of the upper member of the Nantun 1 formation, as a result that the stratum thin and the lithosphere is in equilibrium, which stimulates the passive upwelling of mantle plume and enters the strong rifting period. In the process of strong rifting, the heave uplift zone of the footwall of the main controlling-depression fault develops successively, and the heave uplift zone of the footwall of the sub-fault becomes a favorable hydrocarbon accumulation unit of the sub-level in the depression.

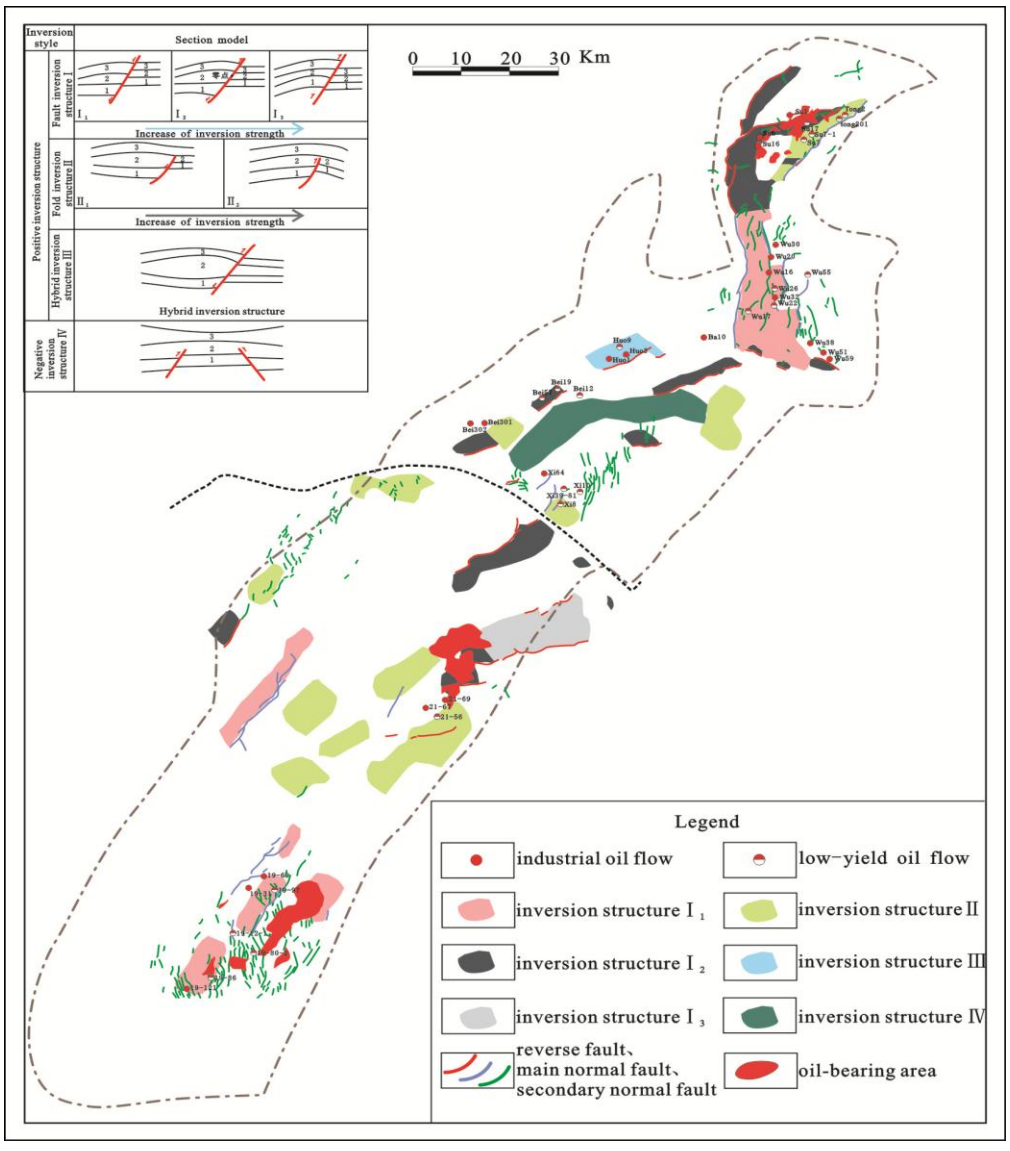

Fig.5 Congruent map of the T_{04} layer's inversion tectonic belt and upper of the layer's hydrocarbon distribution of the middle fault depress belt Hailaer-Tamtsag basin

Besides, more important is the central uplift belt that development in the major fault and controlled by the synsedimentary fault, the uplift is partly inherited the mountains residual basin formed during the buried hill structure, another is controlled by the synsedimentary fault, these ancient uplift are the favorable hydrocarbon enrichment zone. At the end of the sedimentary period of the Nantun 2 formation, the central fault depression zone experienced a period of intense reconstruction, which was the period of structural finalization in the central fault depression zone, and resulted in the formation of the Sudeerte buried hill structural zone, also known as the central uplift zone. In a word, the T_2^2 reflector developed three genetic types of uplift at the stage of strong rifting that the inherited paleo-uplift, the inherited uplift or the newborn uplift, and the newborn central uplift. The central uplift belt which was formed by the strong tectonic movement at the end of the sedimentary period of Nantun formation.From the distribution of hydrocarbon accumulation (Fig.4), the hydrocarbon distribution of Nantun 1 formation had significant correlation with uplift, and the mostly hydrocarbon distribution around of the uplift, and the only partially hydrocarbon of Nantun 2 formation has a certain relationship with the uplift distribution.

3. Inversion structure in the T04 reflector indicates the hydrocarbon distribution of Nantun 2 formation and Damoguaihe formation

The basin entered the stage of depression evolution during the sedimentary period of Qingyuangang formation, which corresponded to a strong transformation. This modification process of basin with a few different with before the phase transformation process, is mainly affected by inversion effect of the central fault belt, inversion period began in the late of Yimin formation sedimentary and tectonic inversion effect is the strongest at this time. Qingyuan formation sedimentary period, formation deposition stable, formation thickness and sedimentary pattern only had little change. After entering the Qingyuan formation, shows that tectonic inversion effect weakened with the apparent tendency, truncation and reverse fault were development in T04 interface, therefore deduce tectonic inversion effect is the strongest period in the late Yimin group sedimentary. According to the new sub-fault for NS, It indicates that the regional stress field is the east-west compressive stress. The tectonic inversion controlled the secondary accumulation of Damoguaihe formation. The hydrocarbon migrated vertically along the inverted normal fault, and then diverged laterally along the fault to the sand body, forming the fault-lithologic hydrocarbon reservoir of the reversed structure (Fig.5).

3. DISCUSSION

The fault depression zone in the middle of Hai-ta basin had contributed to the accumulation of hydrocarbon in different stages of passive rift basin evolution. The fault depression zone in the middle of Hai-ta basin underwent multiple stages of construction, including: the weak reconstruction period of the initial rifting stage (the sedimentary period from lower member to the middle member of the Nantun 1 formation) was mainly affected by the simple shear stress field, which controlled the formation of the uplift zone and the hydrocarbon distribution of the oil-bearing system in lower part of the central fault depression zone. During the period of strong rifting (the sedimentary period from upper member of Nantun 1 formation to Nantun 2 formation), it was mainly affected by the pure shear extension stress field. At the same time, it controlled the formation of the central uplift belt or the central anticline belt of the central rifting belt, and controlled the hydrocarbon distribution of oil-bearing system in the middle part of the central fault depression zone. In the strong reconstruction period of the depression stage (the sedimentary period from the end of Yimin formation to Qingyuangang formation), the development of multiple types of reversed tectonic belts is controlled mainly by the deformation of the compressive stress field, and controlled the hydrocarbon distribution of the secondary oil-bearing system in the upper part of the central fault depression zone.

4. CONCLUSION

1. The Hailar-Tamsag basin is formed by the superposition of two types of basins, the residual basin formed by the Tongbomiao formation and the passive rifting basin formed by the Nantun formation to the Qingyuangang formation. Among them, the passive rifting basin can be further divided into four evolutionary stages: the initial rifting stage in the lower member to the middle member of Nantun 1 formation; the strong rifting stage in the upper member of Nantun 1 formation to Nantun 2 formation; the transformation stage of the Damoguaihe formation to Yimin formation; and the depression stage in the Qingyuangang formation.

2. In different evolutionary periods of the basin, the evolutionary characteristics of the basin were different: in the initial rifting period, the basin is mainly dominated by the strike-slip deformation of simple dextral shear, and a large number of reverse faults and "tilting" tectonic belts are formed in the middle of the basin. During the period of strong rifting, the basin is mainly affected by the nw-se tensile stress field, forming "central uplift" and "central anticline" tectonic belts. During the period of fault-depression transformation, the basin was dominated by the pure shear and tensile deformation in the EW direction, and a large number of fault-intensive structural belts were formed. In the depression period, the basin was dominated by the compressive deformation in the

EW direction, and a large number of inversion structures were formed.

3. Due to the complex structural evolution process in the central fault depression zone, different oil-bearing systems are distributed in different structural belts. Among them, the uplift belt controls the hydrocarbon distribution in the lower member to the middle member of Nantun 1 formation, the central anticline belt or the central uplift belt control the oil and gas distribution in upper member of Nantun 1 formation to Nantun 2 formation, and the reverse structural belt controls the hydrocarbon distribution in the upper part of the dabaguaihe formation.

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