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Control of "Fault-Sand" coupling on Hydrocarbon accumulation of Damoguaihe formation,Wurxun sag

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Abstract: - According to the analysis of structural evolution,the fault system in Wuerxun sag was divided into four types:early extensional faults,interim strike-slip faults, early extensional—interim strike-slip faults,and early extensional—interim strike-slip—late reversed faults.In terms of the relationship of superposed faulting, early extensional—interim strike-slip—late reversed faults played a role of adjustment to hydrocarbon accumulation.At the same time,the research which includes sand distribution and its relation with faults helps us understand that the matching of "fault-sand" controled the Damoguaihe hydrocarbon accumulation.

Keywords: - *Wurxun sag;Damoguaihe formation;Fault system;Accumulational model*

I. INTRODUCTION

Wuerxun sag is a secondary structural unit of Hailar basin[1],and its formation can be divided into Tongbomiao,Nantun,Damoguaihe,Yimin and Qingyuangang from bottom to top (Fig.1).Wurxun sag experienced intensive stretching during Tongbomiao and Nantun sedimentary period.There were few fault activities during Damoguaihe and Yimin sedimentary period which was a transitional period from rifting to depressing.In the late Yimin,Hailar basin experienced the next intensive structural deforming after faulting stage,and the direction of stress field adjusted to approximately EW,forming a lot of nearly NS faults. Meanwhile,the source rock of N1 produced much hydrocarbon which accumulated into the trap forming reservoirs. There were many positive reverse faults and reversal anticlines appeared under the intensively compressive reversal in the late Yimin,and those reversed faults adjusted the hydrocarbon early accumulated in the Nantun reservoirs to the Damoguaihe traps forming the secondary reservoirs[2].

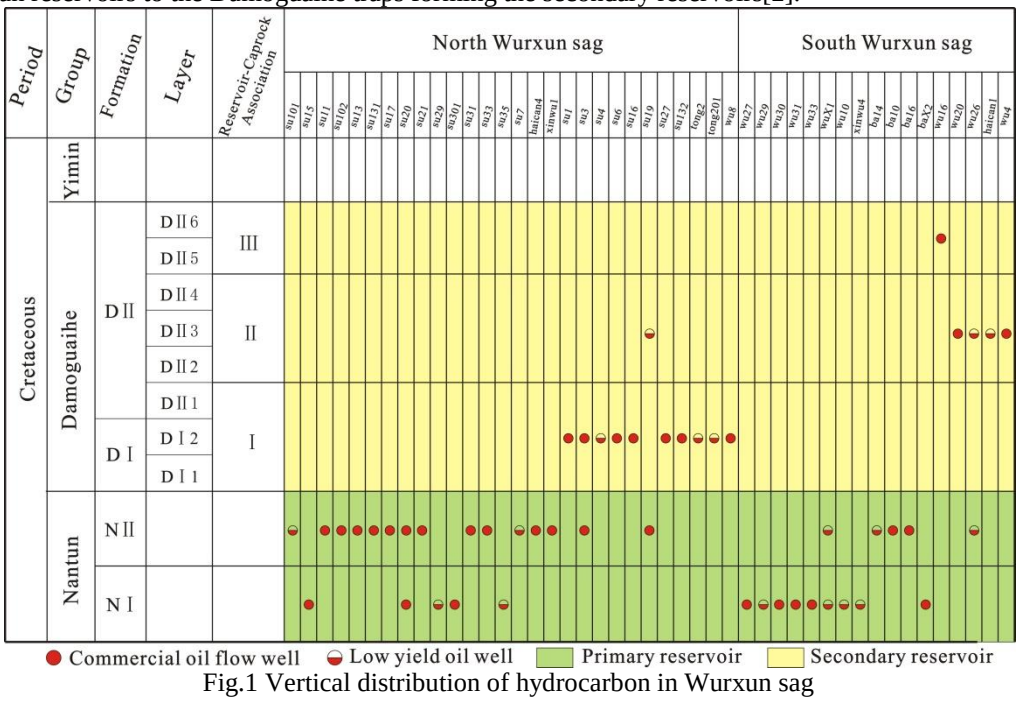

Fig.1 Vertical distribution of hydrocarbon in Wurxun sag

II. DISTRIBUTION OF HYDROCARBON

Nantun and Damoguaihe were the two main oil-bearing formations in Wurxun sag(Fig.1),in which there were 7 commercial oil wells,9 low yield oil wells and 2 oil indication wells(Fig.2).There were some common features of the horizontal distribution between North Wurxun and South Wurxun ,but many differences still existed in vertical.

2.1 The division of reservoir-cap association and vertical distribution

The transition in Wurxun sag moved forward from rifting to depression during Damoguaihe sedimentary period,indicating the changing from rifted-basin filling deposit to depressed-basin filling deposit[3].Three reservoir-cap associations developed in Damoguaihe formation: association Ⅰ, association Ⅱ and association Ⅲ(Fig.1). Association Ⅰwhose sedimentary types gradually changed from braided river delta facies to deeper lacustrine facies to fan delta facies that all belong to transgressive systems developed D Ⅰ1and D Ⅰ2 reservoirs in North Wurxun where there were four commercial oil wells. Association Ⅱwhose sedimentary types gradually changed from meandering delta facies to deeper lacustrine facies to braided river delta facies that all belong to early high stand system tract developed D Ⅱ2-4 reservoirs in South Wurxun where there were two commercial oil wells. Association Ⅲwhose sedimentary types gradually changed from anastomosing river delta facies to shallow lacustrine facies to meandering river delta facies that all belong to late high stand system tract developed D Ⅱ6 reservoir in South Wurxun.

Complementarity is a representative characteristic of hydrocarbon distribution between Damoguaihe and Nantun[4] (Fig.1).It means that there were many commercial oil wells in Damoguaihe but few in Nantun,and there were some commercial oil wells in Nantun but few in Damoguaihe[5].

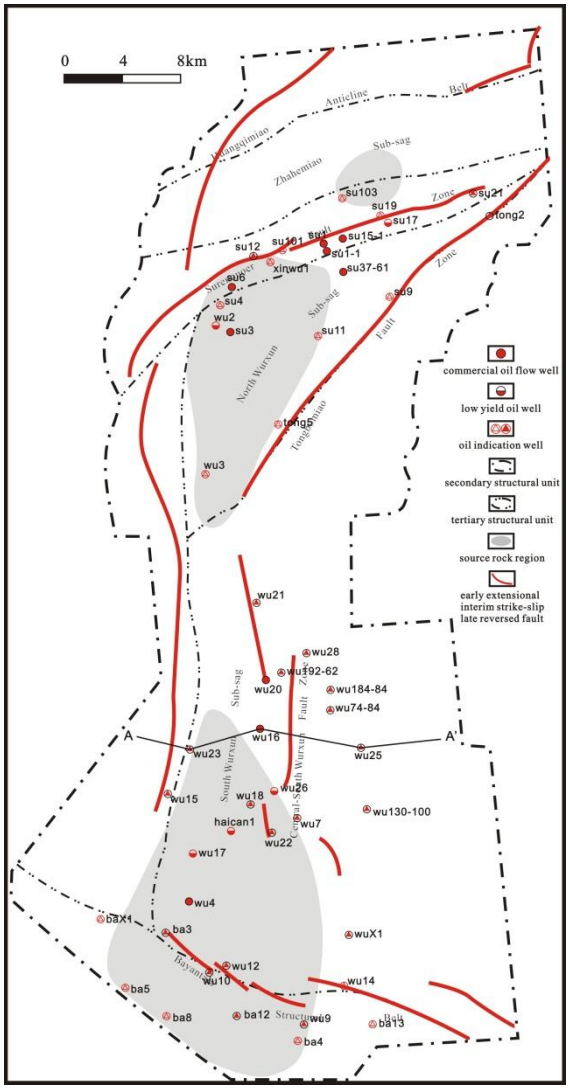

Fig.2 The plan of accumulation elements

2.2 The division of reservoir-cap association and vertical distribution

The horizontal distribution in Wurxun sag was generally controlled by the scope of effective source rock in N1(Fig.2).The faults had the controlling functions to the hydrocarbon accumulation,so there was a special correlation of distribution between hydrocarbon and the trunk faults.A series of fault-lithologic reservoirs developed along the Surennuor fault belt in North Wurxun,such as su3 and su6(Fig.2). A series of SN antithetic faults associated with Wuxi fault on extensional faulted slope-break zone in South Wurxun were the

principal migration pathways of hydrocarbon,and they matched with sands to become the fault-lithologic reservoirs,such as su20-su16 block(Fig.2).Although these faults distributed in different directions ,they had the common feature that they all experienced apparent reversal at the late Yimin sedimentary period[6].

III. THE MAIN CONTROLLING FACTORS OF HYDROCARBON ACCUMUALTION

According to the hydrocarbon distribution and the research of Dong Huanzhong[7],the horizontal distribution of hydrocarbon in Damoguaihe was controlled by the scope of Nantun source rocks which derived from N1 formation.The hydrocarbon in Damoguaihe formation was not directly from N1 source rocks but from N1 reservoirs which were deformed by the structural movement.Because of the lack of hydrocarbon sources,the traps near the channel faults firstly captured the hydrocarbon to form the reservoirs.The development characteristic of Faults and sands was the key factor to the accumulation.

3.1 Early extensional—interim strike-slip—late reversed faults to be the main transporting pathway

The stage of intense faulting deformation in Wurxun included(Fig.3):Tongbomiao-Nantun sedimentary period(early stage),Yimin sedimentary period(interim stage) and late Yimin sedimentary period(late stage).During the extensional deformation phase in early stage,the direction of stress field was SSE-NNW,forming NNE and NEE faults.The stress field in interim stage adjusted to approximately EW,forming a lot of SN faults.Due to the horizontal detachment in Damoguaihe mudstone,faults developed in the later period mostly vanished into the Damoguaihe mudstone.The basin underwent a series of strong reversal movements in the late Yimin period,developing lots of positive reverse faults and reversal anticlines.Based on the relationship of superimposed deformation among the faults,they were divided into four systems(Fig.3): early extensional faults,interim strike-slip faults, early extensional—interim strike-slip faults,and early extensional—interim strike-slip—late reversed faults.

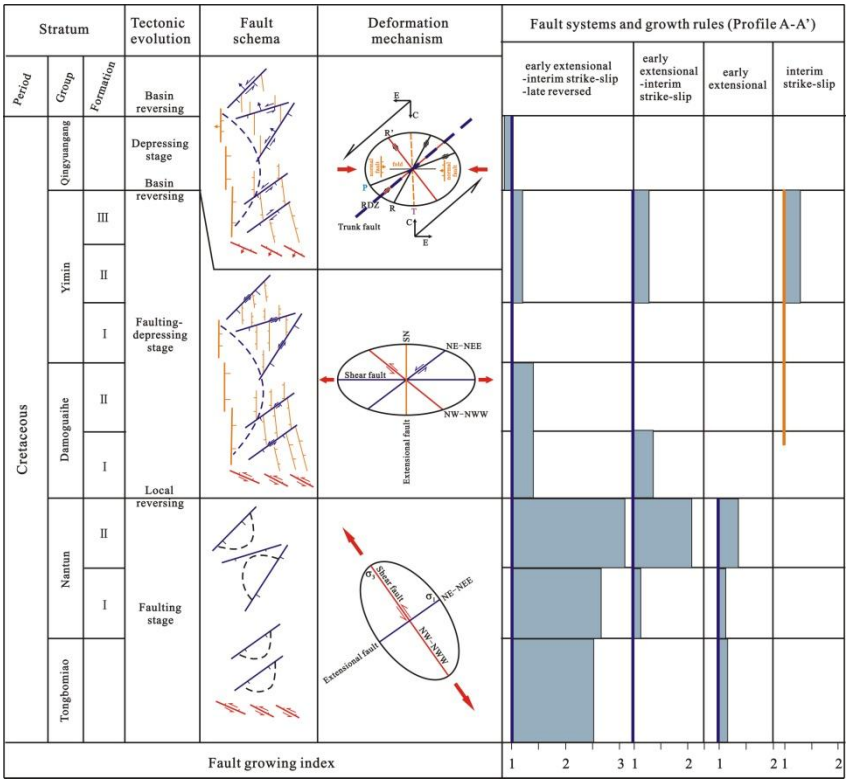

Fig.3 The graph of tectonic evolution and fault deformation in Wurxun sag

Analysing the reservoirs,we discovered that the hydrocarbon in Damoguaihe formation was all controlled by early extensional—interim strike-slip—late reversed faults which could be further divided into two types:positive reversed faults such as Surennuor fault and normal fault on the flank of the reversal anticline such as South-Wurxun central fault. Because these faults cut through several formations,they could interconnect Nantun and Damoguaihe formations.According to the result of researchs,it was the late Yimin when Hailar basin accumulated hydrocarbon and it was also the intense reversal period in the basin. The large-scale fault activities destroyed Nantun paleo-reservoirs,and these active faults which were the hydrocarbon pathway transported the escaped hydrocarbon into the traps in Damoguaihe formation to accumulate again[5-6].

3.2 The controlling of Sand distribution in vertical oil-bearing series and lateral oil-bearing area

Many obvious progradation configurations which displayed as "S" shape in some Damoguaihe seismic profiles showed that fan-delta or delta was the main sedimentary facies in Wurxun sag.In the early Damoguaihe period, early extensional faults generally existed,but they acted weekly.The delta facies developed more broadly,and the area of shallow lake sediment was great,but the area of semi-deep lake facies was little. At this time,fan-delta facies was the major facies and sands developed well in Surennuor fault-belt. In the late Damoguaihe period,the waters broaden and shallowed,and syngenetic faulting became unapparent.Gravity current sediments disappeared basicly and shallow-lake facies developed in all the Wurxun sag.At this time,sands locally and uncontinuously appeared in South-Wurxun faulted slope-break.

Synthesizing sand-layer ratios of different layers(Fig.4),we discovered that sand distribution has obvious vertical stratification in Wurxun sag,but the layers which were rich in sand were different between North Wurxun and South Wurxun.Sands in North Wurxun were chiefly distributed in D Ⅰ1,but Sands in South Wurxun were chiefly distributed in upper D Ⅱ.In Surennuor fault belt,The richest sands developed in D Ⅰ1,and the sand-layer ratios were averagely 35% and maximize to 65%,but the sand-layer ratios of other layers in this region were generally less than 20%.Almost all the commercial oil-producting pays in Surennuor fault belt were located in D Ⅰ1,but there were few hydrocarbon shows in other layers.It can be concluded that there was a close connection between the vertical distribution of hydrocarbon and the layer rich in sands[8].

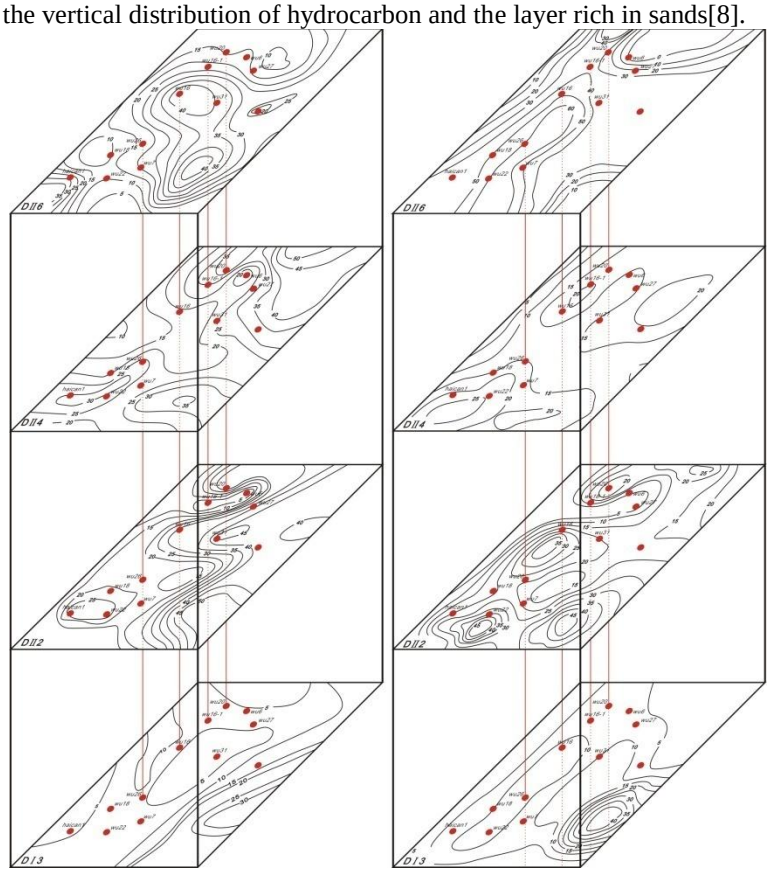

Fig.4 Sand-layer ratios and sands thickness of different layers in Damoguaihe formation

In South Wurxun fault slope-break, Well wu20 and well wu16 respectively had a set of sand body in the top of D Ⅱ,but they uncontinuously developed in different layers.The sand-layer ratio of well wu20 in D Ⅱ4 was 35%,and The sand-layer ratio of well wu16 in D Ⅱ6 was 40%.Well wu16-1 located between well wu20 and well wu16 had different and uncontinuous sands with the two wells(Fig.4). Viewing from the oil testing of the three wells,we can see that well wu20 and well wu16 both had commercial oil-flows in upper D Ⅱ,while well wu16-1 had nothing to show.We can get the conclusion that the oil-bearing area was controlled by the lateral sand distribution.

IV. THE PROCESS AND MODEL OF HYDROCARBON ACCUMULATION

Based on the hydrocarbon distribution of Damoguaihe formation,the accumulation period and the genetic mechanism,the accumulational models could be described as[9] (Fig.5):from the late Yimin sedimentary period to Qingyuangang sedimentary period,the basin experienced a reversal,and fold reversal occurred in South Wurxun sag.The faults on the east-flank of the fold broken up to T_{04},and with the fault activities the

hydrocarbon was adjusted from Nantun reservoirs to Damoguaihe traps,forming the accumulational belt along with well wu20-wu16-wu32.In Surennuor fault belt and Tongbomiao fault belt of North Wurxun,the fault reversal and hybrid reversal occurred and were accompanied with fault activities which were caused by the layer-crossing faults.Some hydrocarbon from the Nantun paleo-reservoirs migrated to Damoguaihe traps,forming the accumulational belt along Surennuor fault.

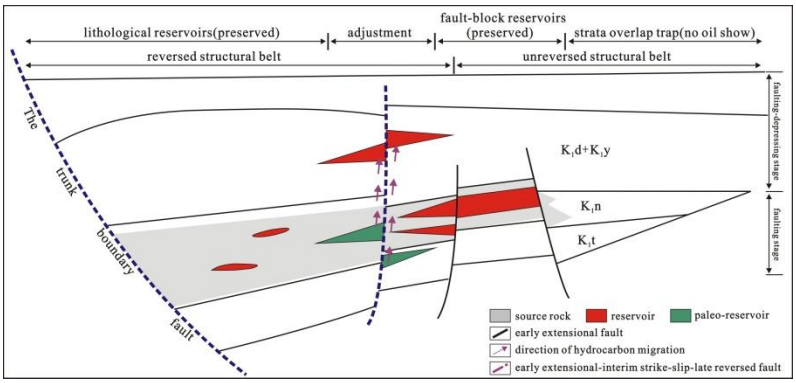

Fig.5 The accumulation model of Wuerxun sag

V. CONCLUSION

There were three reservoir-cap associations from bottom to top in Damoguaihe formation.The hydrocarbon in North Wurxun mainly distributed in association Ⅰand the hydrocarbon in South Wurxun and Bayantala distributed respectively in association Ⅱ and association Ⅲ.Influenced by source rocks,faults and reversal, hydrocarbon laterally distributed on Surennuor fault belt and South Wurxun slope-break.The sands were cut through by faults,and their boundaries decided the oil-bearing area.The type of reservoirs was predominantly fault-lithological reservoir.

The early extensional—interim strike-slip—late reversed faults were mostly acting with the basin evolution,so they became the main pathways for vertical hydrocarbon migration. The reversal structures were a significant feature in Wurxun sag,and the reversed faults adjusted the hydrocarbon in Nantun paleo-reservoirs to traps in Damoguaihe formation,forming the secondary reservoirs.

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