Study on controlling factors of Heidimiao Reservoir formation in Block T121-4 of Aonan Oilfield

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Abstract. There are three types of faults in Block T121-4 of Aonan Oilfield, among which the faults developed from the early Qingshankou and terminated in the Third member of Nenen are the main channels for oil-gas migration. The pre-stack inversion shows that the lame impedance slice can well reflect the reservoir morphological characteristics and the channel characteristics are obvious. During the deposition period from HⅡto HⅠ, the water body changed from deep to shallow, the sedimentary facies transitioned from lakes to deltas, and underwater shunt channels were favorable reservoirs. The formation testing results show that the distribution of oil-gas is closely related to faults and sand bodies, and is the main controlling factor of reservoir formation. The main methods of oil-gas migration are vertical migration and short-distance lateral migration. If the fault-sand coupling relationship is good, oil-gas accumulation can be obtained. The reservoir anatomy shows that there are mainly two types of reservoirs in Heidimiao reservoir in the study area, namely structural reservoir and structural lithologic reservoir.

Keywords: Aonan oilfield; Heidimiao; accumulation; controlling factor.

1. Introduction
Aonan oilfield is located in the south of Aobaota structure in the south of Daqing Placanticline, with Gulong syncline in the west and Aobaota structure in the north and south and Aoxi nose-shaped structure in the east. In 2014, newly drilled Well T121-4 obtained 0.972t industrial oil flow in Heidimiao reservoir, demonstrating that Heidimiao reservoir in Punan Oilfield has great exploration value (Fig. 1).
2. Control Factors Of Accumulation

2.1. Features Of Structural Faults

2.1.1. Fracture formation stage and type division. There are three types of faults in the study area, namely, early and late fault stages. The first type of fault develops early and is active in Qingshankou ~ Mingshui formation for a long time. The second type of fault develops in the early stage and terminates in the late stage. The active period is Qingshankou ~ Nen group, and the active period stops after the 3rd stage of Nen. The third type of fault develops late and is active in the Nengsan ~ Mingshui group.

Through the study of the relationship between fault and hydrocarbon, the results show that the first type of fault plays a destructive role in hydrocarbon accumulation. The second type of fault plays an active role in hydrocarbon accumulation and is a channel for oil and gas migration. The third type of fault is destructive to an already formed reservoir. Because the third type of fault is relatively undeveloped and its influence is limited, only the first type and the second type of fault are analyzed in detail in this paper. The common feature of the first type of fault is that it formed during the Qingshankou period and moved again during the tension torsion deformation in the late deposition of the Nenjiang Formation or the compression torsion deformation in the late deposition of the Mingshui Formation. The profile shows the characteristics of the vertical fault distance of the fault from deep to shallow from large to small, and the fault penetrates the Hedimiao oil reservoir. The plane elongation is long, the plane trend is mainly north west, north west west direction. Take the line985 line in the study area as an example (Fig. 2a). F15 and F17 are the representatives of the first type of faults, which break through several strata such as Qingshankou Formation, Yaojia Formation and Nenjiang Formation. The crude oil formed in the lower Qingshankou formation migrated upward along the fault and passed through Hedimiao reservoir, but it was difficult to form a reservoir. Most of the oil and gas migrated upward until they escaped, which was a typical destructive fault. The second type of fault was formed in the Qingshankou period, but didn't break through the Hedimiao oil layer, but mostly to HII oil layer, vertical section for fault slip from deep to shallow features from large to small. Take the study area Line793 as an example (Fig 2b). F7 and F12 are the representatives of the second type of fault, which started in the Qingshankou Formation, but only ended in the Nenjiang Formation. The termination of fault activity is conducive to the oil from Qingshankou formation moving upward along the fault to Hedimiao reservoir. This type of fault is mainly in the NW, NW or NW direction on the plane, and the plane extension length is slightly less than that of the first type of fault, which is a typical oil-source fault. The third type of fault is mostly developed in late stage of Mingshui formation or Nenjiang Formation. This type of fault shows little change of vertical fault distance in the section and generally spreads in the east-north direction or near east-west direction in the plane. This type of fault is also a destructive fault to the Hedimiao reservoir which has been accumulated. This type of fault has small scale and short plane extension distance.

Fig. 2 (a) Section of the first type of early destructive fault (Line985) (b) Section of the second type oil source fault (Line793)
2.1.2. Relationship between fracture and oil-gas. The practice of oil-gas exploration shows that faults play an important role in the formation and distribution of oil-gas reservoirs. They are not only the transport channel for oil and gas migration, but also the barrier for oil and gas accumulation [1-6].

According to the relationship between faults and hydrocarbon distribution in the study area, crude oil from Well T121-4 came from Qingshankou Formation and migrated to Heidimiao oil formation through F5 fault. In the same way, oil-gas from Well N255-316 migrated to Hedimiao reservoir through F10, while oil-gas in other areas with underdeveloped faults showed little evidence, indicating that the key to Hedimiao reservoir accumulation was the fault.

2.2. Deposition And Sand Body Distribution Characteristics
Heidimiao reservoir corresponds to the deposit in the third and fourth segments of Nenen. In this stage, the provenance mainly comes from the east, and there are mainly two sedimentary subfacies, the progressive front delta front deposition and the Pre-delta deposits. The microfacies sedimentary sand bodies mainly develop underwater diversion channel, underwater diversion bay and sheet sand, followed by estuary dams, remote sand dams and other microfacies [7].

2.2.1. Identification and division of sedimentary facies by pre-stack inversion of Lame impedance.
Using prestack inversion of each small layer of black emperor temple reservoir in reservoir prediction, found the lame impedance inversion time slice can well reflect the distribution pattern of the channel, other facies characteristics are in conformity with the real drilling geological features, including continuous distribution of red ribbon for channel sand body deposition, yellow for thin layer after sand sheet or river shore shore sand, light blue on behalf of lake mud deposition, etc. Using the lame impedance inversion to H1 and HII layers sand group conducted a thin layered inversion. With HI1 and HII2 layer for example, Fig.3a representative HI1 layer deposition period, the two major development in the study area underwater diversion channel, one of which is located in the north of the study area, river to nearly east-west, channel width of about 220-430m, another is in the west of the study area, river to the south east, river width is about 210-390m, research mainly deposition for a wide range of branches bay. Fig.3b for blackI2 layer deposition period, the main channel of development about things, at the same time, main channel in southwest branch of a river, forming a typical Sanchahe. Main channel width HI significantly widen and channel width of 500-750m, the rest of the sediment deposition mainly between bay.

![Fig. 3](image_url) (a) BlackI1pre-stack Lame impedance section (b) BlackI2pre-stack Lame impedance section

2.2.2. HII and HI reservoir formation sedimentary microfacies distribution rule. HII reservoir group is mainly in front delta sedimentary environment, in which HII'small layer deposited in deep water environment, formed a large area of deep lake of mud. HII'small layers of sedimentary microfacies is given priority to with half deep lake deep lake, locally developed some scattered small sand sheet and far sand bars. During the deposition of the HII2 small layer, the lake basin shrinks and the lake water becomes shallower, and terrigenous clastics are relatively increased. The provenance comes from both the southwest and northwest. The sedimentary microfacies changes from a semi-deep lake to a delta
front subfacies, and some banded Underwater diversion channel at the delta front. HI small layers of sandstone distribution area continues to expand, the sedimentary period than HI source direction changes, mainly come from the northeast, sand body scale also widened, flat deposition is given priority to with sand dam and between bay [8-10].

HI reservoir formation sedimentary period, as the shore continues to shrink, rivers influence more, terrigenous coarse-grained material increased, zone sandstone sedimentary thickness increase, the distribution scope. HI to HII sedimentary period is given priority to with delta front subfacies, HI to HII sedimentary period is given priority to with delta plain river. Sedimentary period continues to shallow water than HII period, area edge of sand sheet sedimentary before, far sand dam and underwater diversion bay. HII further becomes shallow water, diversion mouth bar scale, underwater diversion bay between scale atrophy. HII development of underwater diversion channel, underwater natural levee and underwater diversion bay. HI, HII and HI are dominated by underwater diversion channel, natural embankment and inter-bay deposition, in which the channel scale maximized in the whole HII reservoir formation during the Period of HI deposition.

2.2.3. Control effect of sedimentary sand body on oil-gas. Oil and gas in this area are mainly distributed in underwater diversion channels, estuaries, sheet sands and other microfacies. Among them, T121-4 crude oil in the southeast of the study area is distributed in HII middle channel sand bodies, and the distribution of oil, gas and water is obviously controlled by the distribution of sedimentary facies. Due to the limited distribution of underwater diversion channels, crude oil was only seen in wells T121-4 and T40-22. Well N255-316 in the southwest of the study area is in the same bed. Vertically distributed in HII and HI two layers of sand body. The sand body sedimentary environment is still a underwater diversion channel, but the scale of the channel is much larger than that of the T121-4 well area in the southeast. Oil and gas were seen in wells N258-302, M17-52-50 and M17, reflecting that the larger the scale of the sand body controlled by sedimentary facies, the wider the distribution of oil[11-12].

3. Oil And Gas Reservoir-forming Law
Based on the above analysis of reservoir forming control factors such as Heidimao reservoir structure and sand body and their interaction, especially the fault-sand coupling relationship, combined with the distribution characteristics of oil, gas and water, it is concluded that the following reservoir forming laws exist in the study area.

(1) The fault is the main channel for oil and gas migration, and the distribution of oil and gas is closely related to the distribution of fault, and the structural high point is the favorable accumulation area for oil and gas.

In the oil and gas Wells P37, A266-70, Pq12 and T121-4 Hedimiao reservoirs in the study area, they all showed fault migration to reservoir formation. At the same time, these Wells are mostly located at structural or local highs, while other Wells are located in low or fault-free areas where oil and gas is rarely shown. It can be seen that fault is the main channel of hydrocarbon migration in this area.

(2) The scale of sedimentary sand body is positively correlated with the scale of oil and gas and the underwater diversion channel is the most favorable reservoir.

During the sedimentary period of the third and fourth member of Nenen, sediments from the east or northeast were deposited into the lake and formed various kinds of sedimentary bodies in the front of the delta, such as underwater diversion channels, estuarine DAMS and sheet sand, etc. However, the accumulation of oil and gas in different sedimentary bodies is obviously different, and the oil and gas scale in the underwater diversion channel with good physical properties is obviously larger than that in the sheet sand.

According to the analysis of oil and gas distribution characteristics in the study area, there are many oil-gas reservoirs (sand groups) and their surface regularity is poor. The analysis of the reasons is mainly due to the large difference in physical properties of each layer and the uneven distribution of the reservoir plane. Due to the development of reservoir and good physical property, the underwater diversion channel is favorable for the lateral migration of oil and gas.
(3) Vertical migration and short distance lateral migration are the main migration modes, and a good fault-sand coupling relationship is most beneficial to hydrocarbon accumulation.

The vertical migration and short distance lateral migration of the crude oil and natural gas in Heidimiao formation in the study area are the main ones. The oil and gas in the first and the first green and the first tender sections migrated upward through faults and were first filled into reservoirs when they encountered sand bodies with good physical properties. When oil and gas are charged, they tend to migrate laterally, and at the same time, part of the unauthorized oil and gas in the reservoir is further moved upward under pressure to continue the accumulation. Therefore, the traps in the upper and lower plates of faults are often the places where oil and gas are concentrated. Therefore, the good match between fault and sand is the key to accumulation, and only those with good coupling relationship can be the accumulation.

4. Summary and Conclusion

(1) The faults in the study area can be divided into three categories. Among them, the long-term active fault developed in Qingshankou and terminated in Nenjiang Formation plays a role of connecting source rock and reservoir, and is a typical oil-source fault, which plays a positive role in the accumulation of Heimiao reservoir.

(2) HⅡ to HⅠ group sedimentary period, from deep to shallow water, by the transition to lake delta sedimentary facies, underwater diversion channel is favorable reservoir.

(3) The oil test results show that the oil Wells are mainly distributed near the fracture and the main part of sand body, which indicates that sand body and fracture are the main controlling factors of reservoir formation. The comparison between Wells and adjacent Wells in Aonan Oilfield shows that there are mainly two types of reservoirs in Heidimiao reservoir in the study area, namely structural reservoir and structural lithologic reservoir.

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