Main controlling factors and remaining oil distribution in ancient buried hill reservoir

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Abstract. The paleo buried hill in the study area belongs to the metamorphic rock buried hill reservoir, and the reservoir conditions are controlled by the dual factors of structure and dissolution; the comprehensive structural relative difference, the network fracture network characteristics of the reservoir space and the development scale of the secondary dissolution holes are divided into three types of buried hill reservoir; through the comprehensive study of the reservoir characteristics and the reservoir forming conditions of the buried hill reservoir, the source rock fault transport and the fracture and cave development of the buried hill reservoir The main controlling factors for the formation of buried hill reservoir in the study area are the degree of development and sealing conditions. Based on the comparative analysis of a large number of field data such as drilling, oil testing, logging, logging interpretation, oil-water identification and production performance, the trap characteristics, original oil-water interface, rising speed of oil-water interface and water flooded surface condition of buried hill reservoir are clarified, thus guiding the distribution of remaining oil.

1. Geological profile
The buried hill reservoir belongs to a special type of new generation reservoir. Since the 1970s, China has successively discovered and put into development a number of buried hill reservoirs in North China, Shengli, Liaohe and Xinjiang. The reserves of such reservoirs account for about 8% of the total reserves, which is an important field of oilfield development in China [1]. The basin in the study area belongs to an intracontinental extensional fault basin in the rift system of Northeast Asia. Buried hill oil and gas reservoirs have been found successively in many oilfields, especially in the study area, which has the largest scale, oil-bearing area of 29.44km² and geological reserves of 2568.44 × 10⁴t.

2. Main controlling factors of oil and gas accumulation

2.1. Buried hill reservoir type
Many domestic scholars have studied the types of buried hill reservoir, such as Liu Ju et al. (2006) according to buried hill reservoir morphology and oil reservoir seepage characteristics, they can be divided into irregular fracture network reservoir; Ren Lihua (2007) according to buried hill trap genetic type and oil reservoir morphology and other factors, they can be divided into block and irregular fracture network reservoir; Zhang Jiguang et al. (2007) according to fault block buried hill fault shape They are divided into three types: eroded residual hill reservoir, reverse fault block buried hill reservoir and along
fault block buried hill reservoir. Wang Huaai et al. (2009) classified the ancient buried hill into three types, i.e. eroded residual hill reservoir, high fault block reservoir and low fault block layered reservoir according to the different trap genesis, location and reservoir forming characteristics [4-6].

2.2. Main controlling factors of reservoir formation

2.2.1. Effective transport of source rock fracture. Source rock faults refer to those large-scale faults that connect source rock and reservoir, but do not cut through overburden [4]. Hydrocarbon supply window refers to the joint area between source rock fracture and effective source rock. A large number of studies have shown that the accumulation and distribution of oil and gas are closely related to the source rock fracture. The temporal and spatial evolution of the channel function and sealing function of the source rock fracture in the process of oil and gas migration and accumulation determines whether the oil and gas reservoir can finally be formed [5-6].

The comparative study of crude oil components shows that the crude oil of buried hill reservoir in this area comes from the source rock of N group in the adjacent depression, and there are many source rock faults in its structural belt. Through the transport of these source rock faults, the buried hill oil and gas are enriched and formed.

It is found that there are 10 large-scale oil source faults developed in this area, of which 6 faults have large hydrocarbon supply windows with a fault distance of more than 300m, which makes the source rock of the first n member fully connected with the buried hill reservoir and the transport is more effective. In contrast, there are only two source rock faults in the adjacent block, with a fault distance less than 200m, which also provides evidence for the small reserves of the buried hill reservoir in this area.

It is found that the industrial oil flow wells are all distributed within 2.4km from the hydrocarbon supply window.

2.2.2. High quality reservoir space developed on the top of buried hill. The practice shows that the structural position of buried hill reservoir in the study area is positively correlated with the development effect. According to the core porosity and permeability analysis and observation description data, the permeability of buried hill reservoir is \((0.01-592) \times 10^{-3} \mu m^2\), with an average of \(7.64 \times 10^{-3} \mu m^2\); the porosity is \((0.2-22.1)\%\), with an average of 5.63%. Obviously, there are great differences in reservoir physical properties in this area. The high part of the buried hill structure has developed fractures, strong weathering and dissolution, and developed secondary reservoir space. Therefore, the top of the buried hill, especially the high part of the structure, has high oil and gas accumulation, good reservoir physical properties and high production.

According to the statistics of 92 development wells, oil and gas are found from the top of the buried hill to the depth of 296m. The average depth between the oil-bearing bottom and the top of the buried hill is 97.3m, among which 49 high-yield wells with cumulative oil production more than 4000t, 77.6% of the high-yield wells are distributed in the blocks with high to medium high structures, accounting for 86.7%.

2.2.3. Effective shielding of faults. Fault sealing ability is one of the important factors to control hydrocarbon accumulation, and strong sealing fault area can be formed favorable trap. According to the research results of fault sealing, the lateral sealing conditions of faults in the study area are good, which lays a foundation for large-scale oil and gas accumulation.

Taking the monoclinic block buried hill reservoir in the high part of block B6 as an example, a strong sealing normal fault with a fault distance of 94m, an extension length of more than 2.0KM and a fault drop of 200m is developed in the block. The drilling of the descending disk controlled by the strong sealing fault has no oil and gas display, while the ascending disk is rich in a large amount of oil and gas,
forming the largest monoclinic block trap in the buried hill in the study area. The average cumulative production of a single well after development Oil reached 23800 tons.

2.3. Young source in old reservoir forming model

The structural belt of the study area is located on the uplift belt in the center of the depression, which benefits from the structural pattern of the concave middle uplift (close to source oil, thick and wide cap rock). The deep and large faults developed in this area, i.e. oil source faults, provide a channel for oil and gas migration. A large amount of oil and gas generated by the high-quality source rocks of group n, first migrate vertically and backward along the source rock faults and unconformity planes, and then connect the sources in the source area, i.e. oil source faults Oil and gas are enriched in the low part of the structure within the scope of the rock, and then gradually form low fault block to high part of the fault block trap outside the source area to form a stepped accumulation reservoir. At the same time, the overlying thick mudstone is also important as a good caprock, and the reservoir forming mode is "new paleo reservoir" buried hill reservoir.

3. Distribution of remaining oil in buried hill reservoir

3.1. Determination of original oil-water interface

The determination of the original oil-water interface of the fault block buried hill reservoir is helpful to analyze the oil-water distribution of the original reservoir, provide a breakthrough point for the study of the change rule of oil-water, and point out the direction for the distribution of remaining oil.

The rule of oil-water migration and accumulation of buried hill reservoir in the study area is restricted by the structural background of buried hill fault block, fault system and fracture development. Controlled by five main faults, it is divided into three oil-rich zones in the north, the middle and the East. These main faults are all reverse normal faults, which can further divide the buried hill reservoir in the study area into five relatively independent development units. The low part is dominated by oil dryness, and there is no obvious difference in the original oil-water interface between the development units in the bottom water, middle and high parts, but there is a relatively uniform original oil-water interface within the same unit Oil water interface.

3.2. Distribution characteristics of remaining oil

Based on the original oil-water interface trap system and the development time of the oil field as the main line, the analysis method of a buried hill reservoir's watered out condition is mainly based on the new wells put into production in the past years as the inspection wells, and the mutual verification of different layers. Through the understanding of the original oil-water interface, combined with the monitoring and production dynamic data obtained from development, the comprehensive comparative analysis results in the rise of the water-bearing interface in the past years It is confirmed to be practical.

According to the above analysis method, through comparative analysis, the rising speed of oil-water interface in No. 1 trap system is 3.3m/year, and that in No. 2 trap system is 10m / year. The flooded area of oil field accounts for 93.4% of the block area, and the area of UN flooded area accounts for 6.6%.

To sum up, the distribution of remaining oil in buried hill reservoir is controlled by faults, structural shape of buried hill top, water cut rising speed and other factors. The remaining oil is mainly concentrated in the area above the oil-water interface of oil-water system; the remaining oil in water flooded drive is mainly concentrated in the trap transition zone and the pressure conversion concentration zone of oil-water system, all of which are the main directions for further potential exploration. In addition, the injection production ratio should be adjusted in time for the short-term flooded area, otherwise the remaining oil is difficult to be effectively used in the reservoir with strong bottom water energy. At present, there is no effective production technology and method for the buried hill reservoir with such deep flooded area at home and abroad. Therefore, in the early stage of the development of the buried hill reservoir with strong bottom water, the overall development plan of the
buried hill reservoir with strong bottom water capacity should be made to extend Anhydrous and low water cut production period is the key.

4. Conclusion

4.1. The structural belt in the study area is rich in oil sources and has good source reservoir cap assemblages
The most favorable factors for the reservoir formation are the effective transport of source rock faults, the high-quality reservoir space developed at the top of the buried hill and the effective shielding of faults.
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4.2. The buried hills in the study area are divided into three types
According to the relative difference of fault block structure, the characteristics of network fracture network in reservoir space and the development scale of secondary dissolution holes, the buried hills in the study area are divided into three types: low fault step type irregular network buried hill, middle high fault Horst type irregular network buried hill, high monocline type irregular block buried hill.

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