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The Methods to Determine Oil-Bearing Area in Different Types of Reservoirs of Jilin Oilfield

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Abstract
Oil-bearing area is one of the key parameters to calculate geological reserves. Different reservoir types will have different methods to determine oil-bearing area. The statistical analysis of 199 proved development blocks in Jilin oilfield indicates that 92 percent of reservoirs are sandstone reservoirs and fault block oil reservoirs. Reservoir types in Jilin oilfield include lithologic reservoir, structural reservoir and structural-lithologic reservoir. According to the reservoir characteristics and regulation of petroleum reserves estimation in Jilin oilfield, the methods to determine oil-bearing area, which is suitable for different types of reservoir in Jilin, have been summed up. For simple anticlinal structural reservoir, drilling test data is used to determine the oil-water boundary. For fault block oil reservoir, the oil boundary can be composed of fault boundary, oil-water boundary and lithologic boundary. For lithologic reservoir, the lithologic reservoir boundary is determined by probability method and the oil-bearing boundary can be determined by extrapolation method, high resolution seismic or calculating line. For structural-lithologic reservoir, the determination of the oil-bearing area boundary can integrate the methods of structural reservoir and lithologic reservoir

Key words: Jilin oilfield; Reservoir type; Oil-bearing area; Structural reservoir; Lithologic reservoir

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INTRODUCTION
Oil reserve is the basis for guiding oilfield exploration and development as well as determining investment scale. The most common way to calculate oil reserve is the volumetric method. Oil-bearing area is one of the most influential parameters in the reserve calculation accuracy. The determination of oil-bearing area is closely related to the trap type, reservoir heterogeneity and the distribution of water, oil and gas. By analyzing the 199 proved development blocks of Jilin oilfield, reservoir types were summed up and the trap types were determined. According to practical methods to determine oil-bearing area in Jilin oilfield, the methods to determine oil-bearing area in different types of traps were summarized.

1. THE RESERVOIR TYPES OF JILIN OILFIELD
The main exploration areas of Jilin oilfield are Southern Songliao Basin and Yitong Basin. Oil-bearing series in Southern Songliao Basin is Nongan, Fuyu, Gaotaizi, Putaohua, Saertu and Heidimiao reservoir and oil-bearing series in Yitong Basin is Shuangyang reservoir[1-4]. There are 195 proved blocks in Southern Songliao Basin and 4 proved blocks in Yitong Basin (Table 1). The reservoir types of these 199 proved blocks consist of low permeability sandstone reservoir, low

permeability complex fault block reservoir, medium-high permeability complex fault block oil reservoir, medium-high permeability sandstone reservoir, natural energy development reservoir, special type reservoir, thermal heavy crude reservoir, and conglomerate reservoir (Figure 1). 92 percent of the total reservoirs are sandstone reservoir and fault block reservoir. Moreover, according to the statistics of reservoir trap types in Jilin oilfield, the 199 reservoir traps can be divided into three categories: lithologic trap, structural trap and structural-lithologic trap.

Table 1
The Number of Different Oil-Bearing Series Reservoir in Jilin Oilfield

Basin	Southern songliao basin								Yitong basin
Oil-bearing series	Hdm	Set	Pth	Gtz			Fy	Na	Sy
				Qn3	Qn2	Qn1			
The number	6	15	11	29	11	22	100	1	4
Sum	195								4

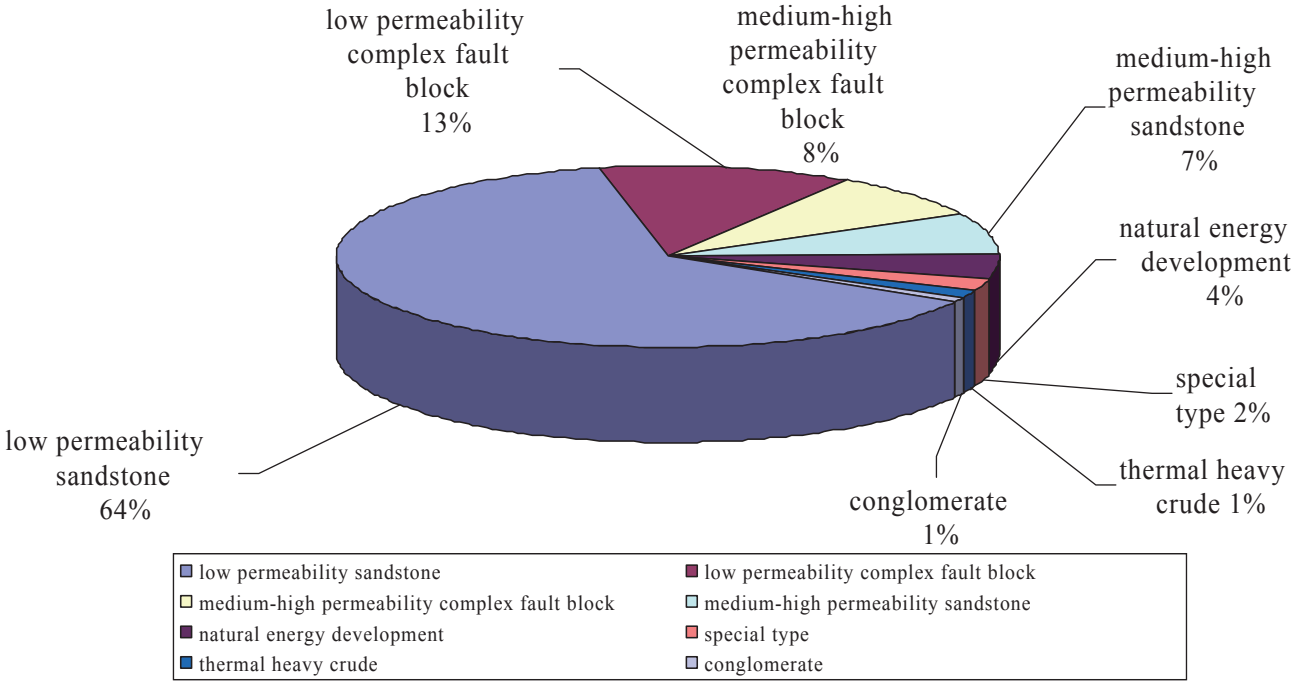

Figure 1
Reservoir Types in Jilin Oilfield

2. THE METHODS TO DETERMINE OIL-BEARING AREA IN DIFFERENT TYPES OF RESERVOIR

The oil-bearing area refers to a range of commercial oil flow and generally refers to planar projection area [5]. The boundary of oil-bearing area is composed of the oil-water boundary, lithologic boundary, fault boundary or many other boundaries. The critical surface of the petroliferous area and nonpetroliferous area is vertical instead of horizontal, when the boundary of the oil-bearing area is delineated by using some particular effective thickness isopleths (Figure 2).

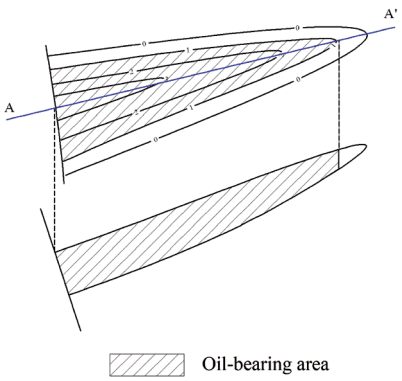

Figure 2
Oil-Bearing Area Bounded by Isopleth

2.1 Lithologic Trap Reservoir

The boundary of the lithologic trap reservoirs generally refers to the plane boundary line where reservoir pinches out. The oil-bearing area used to calculate reserves specifically refers to the boundary line between effective reservoir and ineffective reservoir. In other words, all the wells within the scope of the effective reservoir have commercial oil flow, while the wells within the scope of the ineffective reservoir don't have commercial oil flow or effective thickness. The lithology of effective reservoir is different from that of ineffective reservoir. In general, the lithology of effective reservoir includes the permeability sandstone, conglomerate and fractured mudstone and the lithology of ineffective reservoir commonly consists of compact mudstone, calcareous compact sandstone and relatively low permeability sandstone, etc. According to the analysis of oilfield sedimentary facies, lithologic boundary is mainly developed in river swamp facies, deep lake or seasonal river facies, structure lithologic reservoir, lenticular sandstone lithologic reservoir or sandstone updip pinchout reservoir.

(1) Probability method to determine lithologic deposit boundary

As a result of probability statistics , when the effective thickness between two wells exists zero line, if both wells exist sandstones, the probability of the zero line of effective thickness is the biggest at the midpoint of the two wells and at this time oil-bearing area will cross the midpoint of the two wells; if either of the wells is mudstone, since the end of sandstone pinches out as wedge diminishing, the zero line of effective thickness can be set in the distance which does not reach one third of the sandstone well spacing[6].

(2) Extrapolated method to determine oil boundary

According to the Regulation of petroleum reserves estimation, 1-1.5 times of development well spacing is used to extrapolate calculation line when the boundaries are not proved[7].

(3) High resolution seismic to determine oil boundary

According to the Regulation of petroleum reserves estimation, when reservoir thickness and buried depth are under appropriate condition, fluid interfaces and lithologic boundary predicted by high resolution seismic interpretation, having a high degree of confidence with the constraint explanation of drilling data, can be taken as the basis for delineating oil (gas) area[7].

(4) Using calculating line to determine oil boundary

At early exploration stage of the reservoir, since the understanding of reservoir is not very clear, the range of oil-bearing reservoir can't be determined correctly. In order to estimate the reservoir reserves, the bottom margin of confirming lowest oil and gas entry layers (or well sections), or the cumulative values of the effective thickness are used to delineate oil (gas) area. The value of this effective thickness or extrapolation line can be used as the calculating line. In addition to these two kinds, calculating line can also be a structure line on the structure map, the regular circular or straight line.

2.2 Structural Trap Reservoir

Structural trap reservoir can be divided into simple anticline trap reservoir and fault block trap reservoir. The oil-bearing area of simple anticline trap reservoir is determined by the anticline shape and oil-water interface. Moreover, the anticline shape can be determined by high resolution seismic and oil-water boundary can be determined by the drilling test data or capillary pressure curve. Fault block oil reservoir is more complicated. The oil boundary can be composed of fault boundary, oil-water boundary and lithologic boundary.

(1) Drilling test data to determine oil-water boundary

The same reservoir has the same pressure system and the same oil-water interface[8]. Based on the test data of the same reservoir in this field, combined with the comprehensive geological interpretation and statistical analysis such as the lithology, oiliness, physical and electric property as well as formation test data, the minimum standard of effective thickness was determined. The wells in the reservoir were interpreted for the second time and were divided into oil-water layers and water layers. The depth of oil bottom and the water top on each well were identified. According to the reservoir section or a specific order, the depth of the oil bottom and water top on the graph was marked. By analyzing the characteristics of oil-water distribution, the oil-water interface between the oil bottom and the water top was reasonably divided (Figure 3). According to the altitude of oil-water interface, the inner and outer oil boundary was delineated on the top and bottom of the oil layers of precise structure diagram.

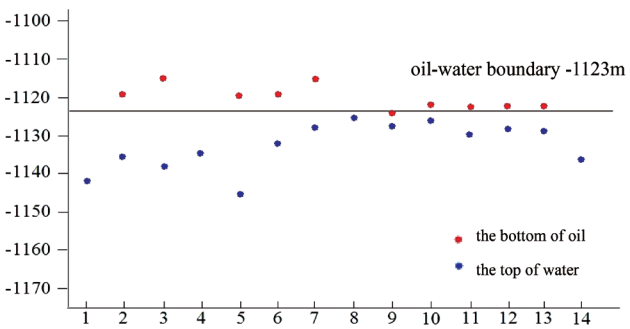

Figure 3
The Oil-Water Interface

(2) Capillary pressure curve to determine the oil-water interface

In order to use capillary curve to determine the oil-water interface, firstly, transform the capillary pressure curve in the laboratory into the capillary pressure curve in underground reservoir and then replace the ordinate from oil-water contact distance to capillary pressure. For determining the oil-water interface of the reservoir, firstly,

determine the oil saturation of a certain depth. Secondly, get the distance to the oil-water interface from the capillary pressure curve. Then, the altitude of oil-water contact interface can be calculated. Finally, the inside and outside oil boundary can be delineated on the top and bottom of the oil layers of precise structure diagram[9].

3. THE METHODS TO DETERMINE THE OIL-BEARING AREA IN JILIN OIL FIELD

The trap types of the 199 proved block reservoir in jilin oilfield include structural trap, structural-lithologic trap and lithologic trap which is dominated. For lithologic trap reservoir in Jilin oilfied, delineating the oil-bearing area adopted the following methods: probability method to determine the lithology reservoir boundary and extrapolated method, high resolution seismic or calculating line to determine the oil boundary. For simple structural trap reservoir, the oil-bearing area is delineated by using oil drilling test data to determine the oil-water boundary. For fault block trap reservoir, the oil-bearing area is delineated by synthesizing the methods of lithologic reservoir and simple structural reservoir.

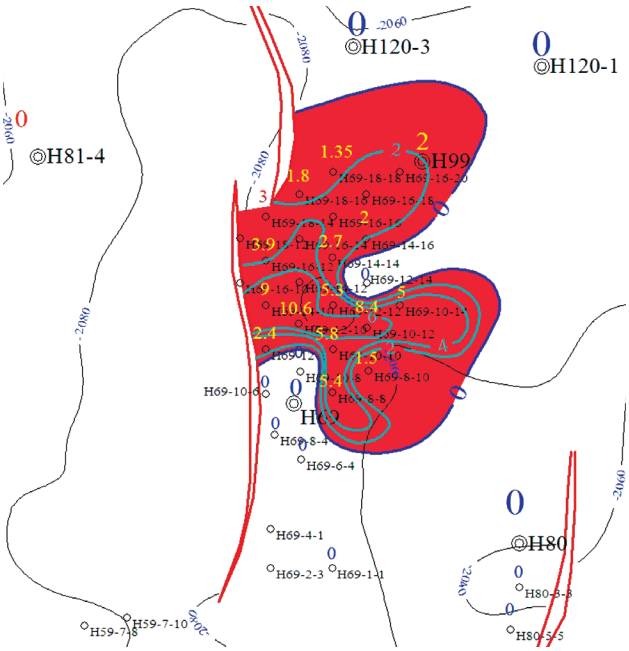

Figure 4
H99 Oil-Bearing Area in Jilin Oilfield

3.1 Structural-Lithologic Reservoir

(1) Fault-lithologic reservoir

In the H99 block of Jilin oilfield, the faults are regarded as calculating line of the western oil-bearing area and the zero line of effective thickness is regarded as the eastern oil-bearing area boundary (Figure 4). The effective thickness of H120-3, H120-1, H69-12-14 and H180 is zero. Probability method is used to determine lithologic reservoir boundary. If there are sandstones in both wells, the probability of the zero line of effective thickness is the biggest at the midpoint of the two wells. Oil-bearing area boundary is determined across midpoints of H99 and H120-3, H99 and H120-1, H69-14-16 and H69-12-14, and H69-8-10 and H80. Furthermore, extrapolated method is used to determine oil boundary and 1-1.5 times of development well spacing is used to extrapolate calculation line when the boundaries are not proved. Oil-bearing area line is across the 1.5 times of extrapolated well spacing point of H69-18-16 and H69-16-18.

(2) Structural-lithologic reservoir

Q173-1 block is at the northeast of Q196 block in Jilin oilfield (Figure 5). According to the sandstone seismic inversion figure and the coordinate figure of the oil bottom and the water top, the sand body in Q196 and Q173-1 is not connected, oil-water boundary of Q173-1 is appeared around the altitude of -1660m (Figure 6), and the oil boundary of Q173-1 is made up of -1660 structural contour and the sandstone pinch-out line (Figure 7).

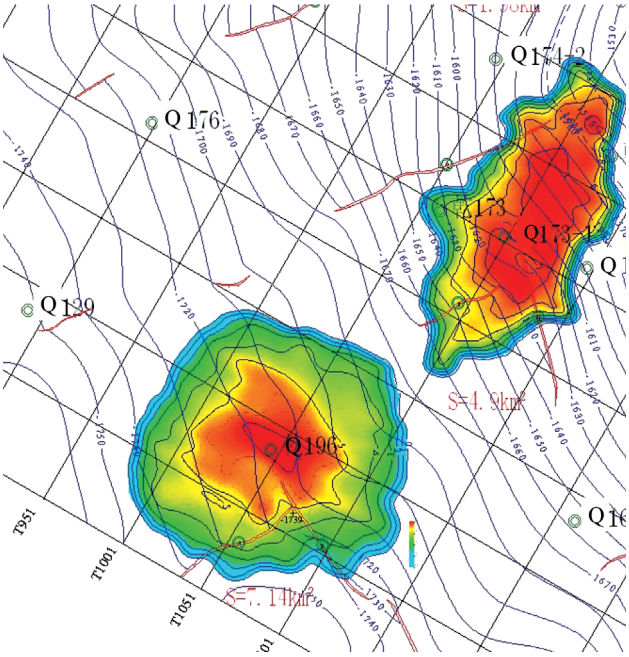

Figure 5
Sandstone Seismic Inversion in Q196—Q173-1 Block

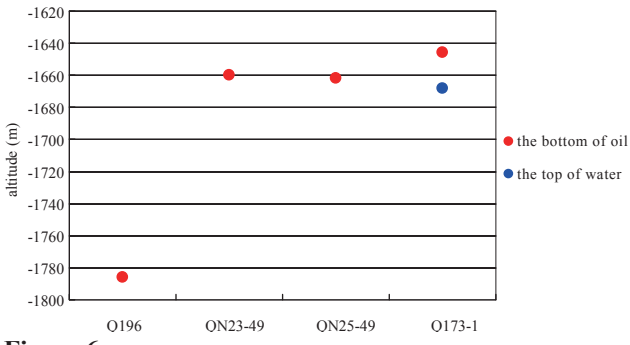

Figure 6
Oil-Water Boundary of Q173-1

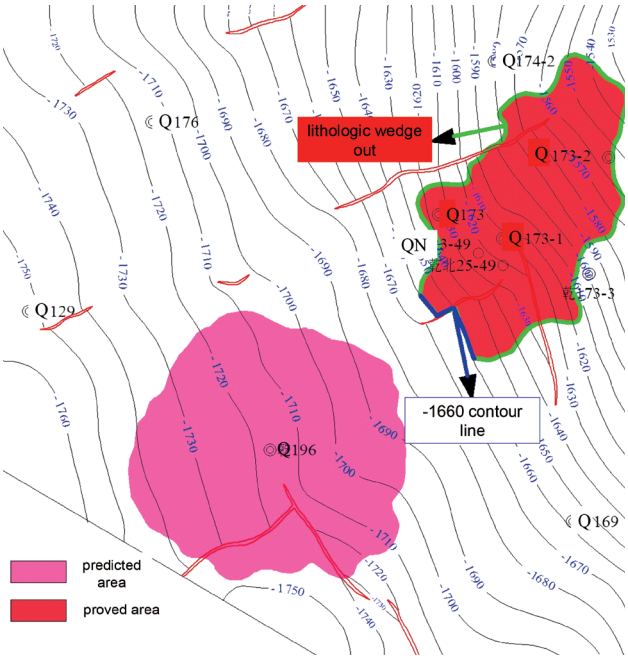

Figure 7
Oil-Bearing Area of Q196 and Q173-1

3.2 Lithologic Reservoir

In the Q196 block of Jilin oilfield, the oil-bearing area can be determined by the oil boundary which is determined by high resolution seismic. When reservoir thickness and buried depth are under appropriate condition as well as fluid interfaces and lithologic boundary predicted by high resolution seismic interpretation, have a high degree of confidence with the constraint explanation of drilling data, high resolution seismic interpretation can be taken as the basis for delineating oil (gas) area. The sandstone pinch-out line and oil-bearing area boundary of Q196 are determined by seismic inversion data (Figure 5, Figure 7). The well in the pinchout body only has Q196. Daily test oil production is 3.1t reaching commercial oil flow (The depth of test layer is 1953 m. According to the Regulation of petroleum reserves estimation, commercial oil production limit of single well is one ton at the depth of 1000-2000 m[7]).

CONCLUSIONS

(1) According to the generalized analysis on the reservoir types of 199 development blocks, 8 types of reservoir in Jilin oilfield are determined, most of which are sandstone reservoir and fault block reservoir.

(2) Oil-water boundary of simple anticlinal structure reservoir is determined by well drilling test data, in order to determine oil-bearing area.

(3) For the lithologic reservoir of Jilin oilfield, the lithologic reservoir boundary is determined by probability method and the oil-bearing boundary can be determined by extrapolation method, high resolution seismic or calculating line.

(4) The method to determine oil-bearing area of fault block trap reservoirs is very complex and can synthesize the methods of lithologic reservoir and simple structural reservoir.

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