

Research of Extent of Well Control of Explored Reserves of Lithologic Deposit in Delta Front Area

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ABSTRACT

Recently the explored reserves submitted in the oil field mainly situate at the end of deposit in delta front area. During the exploitation and production, problems mainly show on lithologic deposit, for example, reserves are low and difficulty of producing is huge. Based on results of sand body dissection of dense well network of developed oil deposit, and combined with explored reserves, this article researches a relation between extent of well control and reserves precision of explored reserves of lithologic deposit in delta front area by well diluted method. This article has significant influence on objectively understanding our unexploited reserves.

Keywords: Delta Front; Lithologic Deposit; Extent of Well Control; Well Diluted Method

1. Introduction

Till the end of 2008, the amount of our explored but unexploited geologic reserves are 2.5122×10^8 tons, including 70.22% unexploited reserves in Putaohua layer of main layer. This part of reserves are mainly distributed in delta front area where is far away from source, sand body is scattered, and the main type of reservoirs is small-sized lithologic deposit.

Submission of explored reserves should satisfy the requirement that completed wells satisfy development plan and can control productive limit or I-aqueous interface. There should be a reasonable extent of well control: relatively high extent causes invention waste and delay of exploration of lithologic deposit; relatively low extent cannot control change of lithologic deposit. Currently, the submitted explored reserves are generally with low extent of well control and hard to effectively control highly hidden lithologic deposit with scattered sand body. Besides, affected by seismic resolution, reservoir forecasting techniques cannot efficiently recognize thin interbedded reservoir, causing low developing degree of reserves.

This article bases on results of sand body dissection of dense well network of Longhupao oil field, Longnan oil field, Putaohua oil field and Gaoxi oil field, applies well diluted method, and researches a relation between extent of well control and reserves precision of explored reserves of lithologic deposit in delta front area.

2. Research of Extent of Well Control of Lithologic Deposit

2.1. Characteristics and Types of Lithologic Deposit

Putaohua layer is mainly located in delta front area; the proportion of its sand ground is moderate; it is oily in wide area, and the type of oil reservoir is mainly lithologic deposit. According to the planform of sand body of reservoir storage, lithologic deposit can be separate into three types: lenticular sand reservoir, banded sand reservoir, and sheet sand reservoir.

Lenticular sand reservoir is mainly located in abandoned channel, mouth bar, and distal bar developing. Sand body is surrounded by non-permeable mudstone; it has independent oil-water systems; oil area is small; the plane distributes separately; sand drilling rate is low, about 30%. Statistics of the accurate dissection of dense well of oil field indicates that the width of lenticular sand body ranges from 100 to 300 meters, and evaluation well is uneasy to be controlled.

Banded sand body reservoir is mainly distributed in channel sand developing area. Space among channels is filled with thin-bed sand sheet or mudstone; aeolotropism of plane is high; strike direction of sand body extends far, and sideway is narrow. Sand drilling rate of sandstone generally ranges from 30% to 40%. Statistics of the accurate dissection of dense well of oil field indicates that the width of banded sand body is between 100 and 350 meters.

Sheet sand reservoir is mainly distributed in sand sheet developing area. The area is large, thickness keeps steady, and Sand drilling rate of sandstone is usually over 60%. Statistics of the accurate dissection of dense well of oil field indicates that the width of sheet sand body is between 300 and 600 meters, which means evaluation well is easy to be controlled.

2.2. Analysis of Current Situation of Extent of Well Control of Developed Lithologic Deposit

The oil field was producing explored reserves of lithologic deposit of Putaohua layer in delta front area, due to low extent of well control, we suffered some problems, for example, producing degree of reserves is low and adjustment of deliverability construction is frequent.

Gaoxi oil field finished drilling 22 evaluation wells in 1983, and submitted 1100.00×10^4 t of triple IOIP, in which the oil area is 53.0km², and the extent of well control is 0.42 well per km². In 1994, we designed 104 drilling wells, in which 8 were finished drilling. After drilling first well and research again, we revised plan: planned well sites were 73 and 31 were canceled.

During the exploitation of drilling wells, according to understanding of rolling drilling geology, we canceled 23 planned wells. In 2002, we recalculated reserves: oil area is 26.8km², finished drilling wells are 25, and the extent of well control is 1.12 well per km². From the history of adjustment, reserves changes with the change the extent of well control.

22 wells in Gulong oil field Gu 571 block were finished drilling in 2007. In explored reserves, the amount of oil area is 46.7km², and the extent of well control is 0.47 well per km². After finishing drilling 97 wells, according to principle of contouring of productive limit of explored reserves, preliminary oil area was cut into 29.8km², and the extent of well control was raised to 2.5 wells per km². One well in Gao 20 district was finished drilling in 2007, in which the oil area is 4.5km², and the extent of well control is 0.22 well per km². 8 wells were rolling drilling in 2009, footage is 14855 meters, and the extent of well control was raised to 2 wells per km². Preliminary the amount of oil area was 1.38km², explored reserves 41.85×10⁴t, and average reserves is 0.0028×10⁴t per meter of footage. Because of the low extent of producing reserves, the risk of exploitation is huge.

2.3. Relation between Extent of Well Control and Reserves Precision of Explored Reserves

Reasonable extent of well control is a key to explore reservoirs and to effectively exploit. Especially, using the location of evaluation wells to evaluate lithologic deposit in reservoir bed with multivariant lithologic characters can hard to understand rules of geology, thus bringing big exploitation risks. On the contrary, to small-sized lithologic deposit, unreasonable extent of well control often causes excess of drilling wells.

Calculation formula of IOIP by volumetric method:

$$N=100\rho_o A_o h \Phi (1-S_{wi}) / B_{oi}$$

Parameters description: N, IOIP, 10⁴t; A_o, Oil Area, km²; h, Effective Thickness, m; Φ, Active Porosity, <0; S_{wi}, Initial water saturation; ρ_o, the density of STO, t/m³; B_{oi}, Oil Volume

Factor, m³/m³;

According to parameters in formula, the extent of well control has different influence extent on different sandstone stypes of lithologic deposit.

To lensing reservoir, because the area is small, influence on reserves by extent of well control is mainly variation of oil area (A_o); to banded sand body reservoir, due to its banded distribution, influence on reserves by extent of well control is mainly variation of oil area (A_o) either; And to sill-like reservoir, since its reservoirs are well continued and area is big, influence on reserves by extent of well control is mainly variation of Effective Thickness (h).

In order to study the relation between extent of well control and reserves precision of explored reserves of lithologic deposit, we start at results of the accurate dissection of dense well of sand body of Longhupao oil field, Gaoxi oil field, Longnan oil field, and Puxi oil field, and expand our research by using well diluted method. This article, starting at extent of well control 16 wells per km², made statistics of proportions of omission of sandstone under different extent of well control. (Figure 1).

According to Figure 1, when extent of well control reaches 6.25 wells per km², the proportion of omission of sandstone is about 50%. Therefore, to control sand body above 50%, the extent of well control cannot be below 6.25 wells per km².

In order to explain that different extent of well control has different influence on reserves precision, we selected 4 oil fields with 49 typical lithologic deposits in different types, and finally made statistics and regression of errors in explored reserves under different extent of well control. (Shown in chart 1).

Errors in reserves of three types of lithologic deposits become larger with decreases in extent of well control. Besides, extent of well control affects reserves precision of sill-like reservoir less than affects that of lensing reservoir and banded reservoir. \

In light of the different requirements to errors in explored reserves with various levels, we can summarize extent of well control of explored reserves with different kinds of reservoirs.

Oil Field	Number of Sandstone	Extent of Well Control											
		16 wells/km ²		11.1 wells/km ²		6.25 wells/km ²		4 wells/km ²		1.56 wells/km ²		1 well/km ²	
		Number	Proportion	Number	Proportion	Number	Proportion	Number	Proportion	Number	Proportion	Number	Proportion
Gaoxi	92	26	28.3	33	35.9	44	47.8	73	79.3	84	91.3	85	92.4
Puxi	260	52	20.0	83	31.9	104	40	175	67.3	185	71.2	227	87.3
Longnan	419	116	27.7	136	32.5	249	59.4	261	62.3	370	88.3	373	89.0
Longhupao	271	26	9.6	52	19.2	82	32.9	172	63.5	219	80.8	236	87.1

Figure 1. Statistics of omission of sandstone under different extent of well control in delta front area.

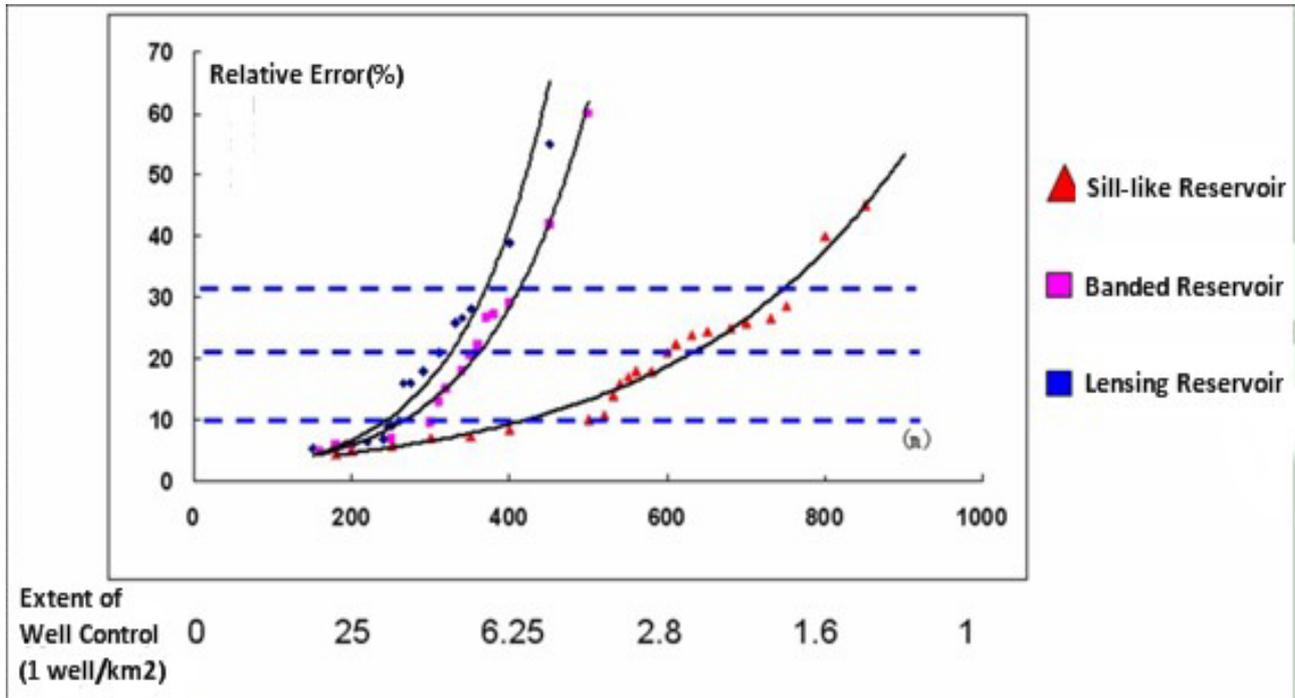


Chart 1. Relation between reserves precision and different extent of well control.

	Explored Reserves Produced (Type I)	Explored Reserves Unproduced (Type II)	Basic Explored Reserves (Type III)
Lenticular sand body reservoirs	>16	11.1~16	8.2~11.1
Banded sand body reservoirs	>11.1	8.2~11.1	6.25~8.2
Sheet sand body reservoirs	>6.25	2.8~6.25	1.8~2.8
Relative Error (%)	10	20	30

Worthy to mention that the winding of rivers causes diversification and irregularity of lithologic deposits, especially banded reservoir. This evaluation of reservoirs is not fully applicable to conventional standard well network. Thus, people should flexibly design pattern configuration in different types of reservoirs by utilizing research findings of extent of well control. It has been found that it is better to use well network with regular dimensions in sill-like reservoir but to use “S” pattern in banded reservoir---well spacing can expands along with strike direction of sand body while horizontal distance is better to be limited within the width of wave of sand body, not only accelerating evaluation but also well controlling oil area and improving evaluation precision.

3. Conclusions & Suggestions

3.1. Conclusions

First, in delta front area, the width of lenticular sand body reservoir ranges from 100 meters to 300 meters, banded sand body reservoir from 150m to 350m, and sheet sand body reser-

voir from 300m to 600m.

Second, producing degree of explored reserves of lithologic deposits in delta front area mainly depends on extent of well control. In order to control sand body above 50%, the extent of well control cannot be below 6.25 wells per km2.

Third, according to different requirements to reserves precision with different level, lower limit of extent of well control of explored reserves of lensing reservoir, banded reservoir and sill-like reservoir is 8.2 well per km2, 6.25 wells per km2, and 1.8 wells per km2 respectively.

3.2. Suggestions

In exploitation and production of explored reserves in delta front area, we should firstly develop well, enhance extent of well control and strengthen geology knowledge, and then develop exploitation wells and decrease drilling risks.

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