Analysis on the difference of producing state of oil layers in Changyuan area and its causes

Haiping Wang

Reservoir Evaluation Room, Institute of Geology, Fourth Oil Production Plant, Daqing Oilfield Co., Ltd., Daqing 163000, China

Abstract. In view of the differences in the production status of non main reservoirs in the old area of Changyuan, combined with dynamic and static data, this paper runs a comprehensive analysis method, through the production analysis of different reservoir groups and different sand body types, studies and analyzes the causes and distribution characteristics of long-term non main reservoirs, and defines the methods and supporting adjustment technologies to improve the production status of thin and poor reservoirs.

Keywords: Sedimentary type, Sand body contact relationship, Difference in utilization status.

1. Introduction

In view of the phenomenon that the non-main reservoirs in the old Changyuan area have not been used for a long time, in order to further improve the production status of thin and poor reservoirs, starting from the influencing factors such as plane contradiction, interlayer contradiction and injection-production relationship, this paper emphatically analyzes the causes and distribution characteristics of the non-production reservoirs, and defines the methods and matching adjustment technologies for improving the production status of thin and poor reservoirs. Provide technical support for effective development and production of oil layer.

2. Analysis of production status of non-main oil layers

2.1 Difference analysis of utilization status

The production status of non-main oil layers is unbalanced. Vertically, Sa II and Sa III are better, while Portugal I and Sa III are worse.On the plane, the inner front and outer front facies are better in type I and II, outer front facies are in poorer type III and IV, and off-surface reservoir production is poor.

Table 1. Production status of different reservoir groups

Reservoir group	Accumulated use at the end of 2009		
	Number of layers（%）	Sandstone（%）	Effective（%）
SaGroup II	74.47	80.37	83.51
SaGroup III	55.97	65.81	75.69
PuGroup I	47.23	54.14	66.99
PuGroup II	39.17	46.41	65.89
GaoGroup I	10.56	16.11	25.77
Total	55.21	63.22	73.34

Table 2. Table of Production Status of Different Sedimentary Types

Sedimentary type		Accumulated use at the end of 2009		
		Number of layers（%）	Sandstone（%）	Effective（%）
Inner leading edge phase		61.72	64.57	60.62
Outer front phase	Class I	70.15	76.31	80.92
	Class II	64.62	70.10	78.24
	Class III	42.00	45.90	65.23
	Class IV	28.05	24.38	59.32
Total		55.21	63.22	73.34

Table 3. Production status table of different sand body types

Sand body type	Accumulated utilization at the end of 2011		
	Number of layers（%）	Sandstone（%）	Effective（%）
Channel sand	80.00	81.27	80.09
Main thin layer sand	77.41	77.75	76.74
Non main thin layer sand	64.68	67.70	65.33
Off surface reservoir	40.31	45.73	0.00
Total	55.21	63.22	73.34

The proportion of intermittent production is higher than that of continuous production, and the proportion of interval and continuous production layers reaches 58.1%

and 41.9% respectively. Vertically, SA II group is mainly used continuously, and SA III group and below have a high proportion of intermittent use.On the plane, the proportion of intermittent use and continuous use of thick layers inside the table is the same, while the gap use is the main use of thin layers inside and outside the table.
Taking the water well as the center, calculate the influence of the contact relationship between the sand body of the surrounding connected perforated oil well and the sand body of the water well on the production status. Mutant water absorption is the worst.

Table 4. Table of Usage of Different Types of Contact Relations

Type	Proportion of total water absorption（%）		
	Number of layers	Sandstone	Effective
Uniform	11.96	10.08	7.40
Gradient	11.24	11.95	14.62
Mutant	2.14	2.56	3.45
Complex	14.29	19.17	24.55
Total	56.99	62.63	70.01

In the uniform type, the main body and the main body, and the river channel and the river channel, although the use is better, but the ratio of the number of layers is relatively low. The proportion of the number of outer layers reached 77.62%, resulting in a lower utilization rate of the uniform type than that of the complex type.The same is true for gradient.

Table 5. Table of Usage of Uniform Contact Relationship

Type	Layer ratio（%）	Percentage of type water absorption（%）			Percentage of uniform water absorption（%）		
		Number of layers	Sand stone	Effective	Number of layers	Sand stone	Effective
Table to table	77.62	48.31	49.71	0.00	37.50	31.03	0.00
Non-to-non	12.79	77.27	83.76	81.54	9.88	12.96	23.04
River to river	0.58	100.00	100.00	100.00	0.58	1.97	6.09
Master to master	9.01	61.29	58.59	52.98	5.52	11.80	34.78
Total	100.00	53.49	57.76	63.91	53.49	57.76	63.91

Table 6. Gradual contact relationship utilization table

Type	Layer ratio（%）	Percentage of type water absorption（%）			Percentage of uniform water absorption（%）		
		Number of layers	sandstone	Effective	Number of layers	sand stone	Effective
River to lord	2.13	100.00	100.00	100.00	2.13	4.31	12.48
Lord to the River	1.28	100.00	100.00	100.00	1.28	2.34	3.38
Main to non	14.47	91.18	91.93	94.59	13.19	19.17	30.84
Non-main	7.23	82.35	87.43	85.45	5.96	6.28	6.90
Non-to-list	44.26	37.50	63.74	64.19	16.60	26.19	27.90
Table to non	30.64	69.44	74.92	0.00	21.28	18.14	0.00
Total	100.00	60.43	76.44	81.50	60.43	76.44	81.50

2.2 Distribution characteristics of unused oil layers

The long-term non producing reservoirs are vertically concentrated in SA III group and Pu II group. The upper oil layer to the lower oil layer increase successively, the long-term unused oil layers below the Pu II group have reached more than 50%, and the high I group has more than 80% unused.

Table 7. Distribution of unused oil layers in each oil layer group

Reservoir group	Undeveloped reservoir			Proportion in each reservoir group（%）			Proportion in total（%）		
	Number of layers (PCs.)	Sandstone（m）	Effective（m）	Number of layers	Sand stone	Effective	Number of layers	Sandstone	Effective
SaII	75	55	11	10.7	7.2	4.9	12.0	11.2	14.5
SaIII	161	89	10	25.0	15.9	6.9	25.8	18.3	12.9
PuI	94	91	15	40.0	34.1	23.4	15.0	18.7	19.4
PuII	181	156	16	50.3	43.7	25.4	29.0	32.1	21.7
GaoI	114	96	24	80.3	74.8	66.1	18.2	19.6	31.4
Total	625	487.5	75.1	30.0	23.5	14.3	/	/	/

The long-term non producing reservoirs are concentrated in class III and class IV of outer front facies on the plane.The proportion of long-term unused oil layers in outer front facies III+IV is 65.4%, and the proportion of layers in outer front facies III and IV is over 40%.

Table 8. Distribution of unused layers in each deposition type

Sedimentary type		Undeveloped reservoir			Proportion in each sedimentary type (%)			Proportion in total (%)		
		Number of layers (PCs.)	Sandstone (m)	Effective (m)	Number of layers	Sandstone	Effective	Number of layers	Sandstone	Effective
Inner leading edge phase		57	79.8	29.8	27.3	24.7	29.0	9.1	16.4	39.7
Outer front phase	Class I	96	86.5	18.8	16.5	11.2	8.1	15.4	17.7	25.0
	Class II	63	39.6	4.6	17.5	13.3	5.3	10.1	8.1	6.1
	Class III	365	255.8	20.1	42.9	40.6	20.6	58.4	52.5	26.8
	Class IV	44	25.8	1.8	53.7	58.2	30.5	7.0	5.3	2.4
Total		625	487.5	75.1	30.0	23.5	14.3	/	/	/

The long-term unused oil layer is concentrated on the non-main thin sand and off-surface reservoirs on the plane. Non main thin layer sand and off surface reservoir account for a large proportion, of which the number of layers of off surface reservoir accounts for 72.8%. From the proportion of long-term non producing reservoir in each sand body type, the off surface reservoir is still high.

Table 9. Distribution of unused oil layers in each sand body

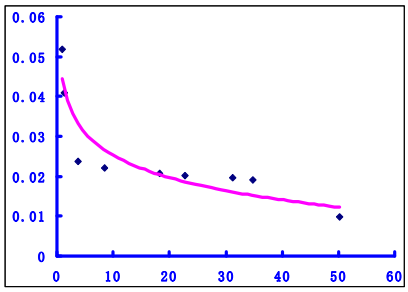
Sand body type	Undeveloped reservoir			Proportion in each sand body (%)			Proportion in total (%)		
	Number of layers (PCs.))	Sandstone (m)	Effective (m)	Number of layers	Sandstone	Effective	Number of layers	Sandstone	Effective
River sand	3	6.8	5.4	12.0	11.1	12.1	0.5	1.4	7.2
Main body thin layer sand	44	65.0	36.0	10.4	9.8	11.4	7.0	13.3	47.3
Non-subject thin sand	123	115.6	34.2	21.0	19.9	20.2	19.7	23.7	45.5
Off-surface reservoir	455	300.2	/	43.5	39.3	/	72.8	61.6	/
Total	625	487.5	75.1	30.0	23.5	14.3	100.0	100.0	100.0

2.3 Cause analysis of unused oil layer

Combined with various dynamic monitoring data, it is considered that the main influencing factors of the unused oil layers are large interlayer contradiction, poor oil layer development and imperfect injection and production. The proportion of poor development of oil layers is the highest. The proportions of each oil layer group, each sedimentary type, and each type of sand body are quite different. Among them, there are great interlayer contradictions in SA II formation, Pu II formation and Gao 1 formation, class III of outer front facies, the proportion of off surface reservoirs is high, the oil layer development is poor, class III of outer front and off surface reservoirs account for a high proportion in Pu II formation, and the injection production is imperfect. The distribution of each oil layer group is relatively uniform. In each sedimentary type, class III and class I of outer front facies are higher, and in each type of sand body, The proportion of non main thin sand and off surface sand is high. First, there are big contradictions between layers.

It is mainly affected by interlayer interference, accounting for 46%. Vertically, affected by the heterogeneity of oil layers, various oil layers are superimposed and distributed alternately, and the water absorption difference between layers and between small layers within layers is large, and even single-layer breakthrough occurs. It is mainly distributed in off surface reservoir and non main thin layer sand.

Second, the starting pressure is high. The lower the permeability, the higher the starting pressure gradient. When the permeability is less than 10×10-3μm2, the starting pressure gradient increases sharply. Analyzing from the schematic diagram of pressure difference, the difference in fracture pressure between the upper and lower oil layers is relatively large. The Pu I4 and lower oil layers are deeper and the starting pressure is higher. They are mainly developed as off-surface reservoirs, making this part of the oil layers difficult to produce.



Start-up pressure gradient and permeability curve

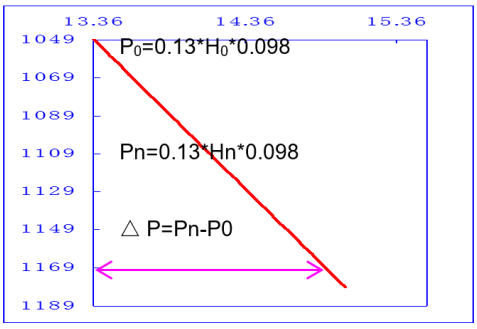


Diagram of pressure difference

Fig.1 Start-up pressure gradient and permeability curve and

Table 10. Production status table of oil layer groups with different permeability levels

Reservoir group	Water absorption ratio of different permeability grades（%）							
	《10（10-3μm2）		10～100（10-3μm2）		100～200（10-3μm2）		〉200（10-3μm2）	
	Number of layers（%）	Sandstone（%）	Number of layers（%）	Sandstone（%）	Number of layers（%）	Sandstone（%）	Number of layers（%）	Sandstone（%）
Sa groupII	88.03	91.55	98.39	98.77	100	100	100	100
Sa group III	66.67	80.79	72.43	91.67	95.45	97.97	100	100
Pu group I	0	0	58.42	54.8	58.82	64.71	81.25	82.19
Pu group II	44.86	50	81.82	91.07	92.31	95.37	100	100
Gao group I	0	0	17.8	24.51	27.78	27.09	33.33	25.86
Total	67.71	74.11	81.82	83.67	89.68	90.32	87.5	97.85

With the decrease of permeability, the production of oil layer becomes worse, and the production of upper oil layer is better than that of lower oil layer, which is more obvious when the permeability is less than 10 millidarcy.

Third, the reservoir development is poor. It can be divided into poor development of this well and poor development of surrounding sand bodies, accounting for 30.2% and 12.8% of the layers that are not used, respectively. Among them, the manifestation of poor well development is that this well is poorly developed, and the surrounding sand bodies are better than this well; By comparing the oil layer properties of poorly developed sand body, non-absorbent layer and absorbent layer, it is found that the thickness, permeability and porosity of poorly developed sand body are low, which is lower than the average level of the block, indicating that this part of sand body is difficult to produce due to poor physical properties. Among them, the poorly developed oil layers in this well are all off-balance sheet development.

The fourth is imperfect injection and mining. It is divided into imperfect injection production relationship caused by fault edge, poor perforation correspondence, poor sand body shielding and no perforation of surrounding oil wells. It is vertically distributed in SA III group and Pu II group, and horizontally distributed in class III sand body of outer front facies, non main thin layer sand and off surface reservoir.Among them, the proportion of poor perforation correspondence and poor sand block is high, and the perforation correspondence of water wells developed into channel sand is poor, and most water wells developed into non-main thin sand have poor sand block.

Table 11. Analysis of reasons for poor development of oil layers in different types

Imperfect type	River sand		Main body thin layer sand		Non-subject thin sand		Off-surface reservoir		The proportion	
	Floor(%)	Sandstone (%)	Floor(%)	Sandstone(%)	Floor(%)	Sandstone (%)	Floor(%)	Sandstone(%)	Floor(%)	Sandstone (%)
Poor perforation correspondence	8.00	7.17	2.12	2.09	1.88	1.48	2.67	2.87	29.24	29.59
The surrounding oil well is not perforated	0.00	0.00	0.00	0.00	0.85	0.69	0.67	0.64	7.02	5.40
Variation sand body occlusion	4.00	3.91	1.65	1.87	9.22	8.98	2.39	2.25	58.48	57.13
Fault edge	0.00	0.00	0.71	0.84	1.54	1.62	0.96	1.05	12.87	13.95
Total	12.00	11.07	4.47	4.80	13.48	12.77	6.69	6.80	100.00	100.00

3. Countermeasures shall be taken according to the cause types

Combined with the causes of long-term non producing reservoir, the injection production structure is adjusted from two aspects of injection end and production end, focusing on three means: reducing interlayer contradiction, enhancing seepage capacity and improving injection production relationship. Active measures have been taken to increase injection, subdivision, overhaul, pump replacement and water plugging in 145 well times, totaling 1,581 sublayers.

Table 12. Improving the technical situation of digging remaining oil

Adjust your thinking	project	Jing second	Layers of different sand body types (PCs.)				
			River sand	Master thin	Non-primary thin	Off-balance sheet	Total
Alleviate conflicts between layers	Subdivision	62	1	36	45	91	173
	Profile control	5	0	7	14	16	37
	Water blocking	8	0	1	6	8	15
Subtotal		75	1	44	65	115	225
Enhance seepage capacity	Bolster	32	17	95	143	300	555
	Increase production	24	1	43	81	197	322
Subtotal		56	18	138	224	497	877
Improve the injection-production relationship	Fill holes	1	6	12	5	0	23
	Overhaul	8	38	105	88	114	345
	Pump replacement	5	9	17	36	49	111
Subtotal		14	53	134	129	163	479
Total		145	72	316	418	775	1581

The utilization degree of the block has been significantly improved, the proportion of layers has increased by 14.79%, and the proportion of sandstone has increased by 13.25%. It mainly improves the surface inner layer and surface outer layer with an effective thickness of 0.5m-1m.

Table 13. Table of the effect of improving oil reservoir production

Classification		Improve the injection-production relationship (%)		Alleviate conflicts between layers (%)		Enhance seepage capacity (%)		Total (%)	
		Number of layers	Sandstone	Number of layers	Sandstone	Number of layers	Sandstone	Number of layers	Sandstone
In the table	Effective ≥2m	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	1m-2m	0.00	0.00	5.77	9.84	2.88	6.31	8.65	16.16
	0.5m-1m	3.23	1.35	11.14	9.68	4.40	2.64	18.77	13.67
	< 0.5m	2.05	1.69	7.68	7.49	3.75	3.55	13.48	12.72
	Subtotal	2.22	1.26	8.59	8.62	3.86	3.62	14.67	13.50
Off-balance sheet		2.96	2.55	8.69	8.40	3.63	3.49	15.28	14.44
Total		2.59	1.74	8.64	8.54	3.74	3.57	14.79	13.25

4. Conclusion

(1) Affected by large interlayer contradictions, poor reservoir physical properties and imperfect injection production, the production of non main reservoir is unbalanced. The long-term non production layers are mainly distributed in SA III and Pu II groups, class III and IV of outer front facies, non main thin sand and off surface reservoir.

(2) Different contact relationships of sand bodies determine the producing degree of oil layers, and the producing condition decreases with the development of sand bodies getting worse. Among them, the complex type has a high production ratio, while the uniform type and gradual type are relatively poor in production because most sand bodies are surface-to-surface, surface-to-non and non-to-surface contact.

(3) In response to the various contradictions of the oil layer, starting from the treatment of long-term unused and poorly produced layers, continuously adjust and improve the injection-production structure, improve the production status of the oil layer, increase the recoverable reserves, and ensure the development effect.

References

1. Zu Xiaojing. "Study on Methods for Improving the Production Degree of Off-surface Reservoirs", Excellent Papers Collection of Xingbei Development Zone, Daqing Oilfield
2. Li Yikun, Zhang Yongjun, Zhao Fulin, Wang Zhengkun. Research and application of pressure gradient distribution map. Journal of Jianghan Petroleum Institute. 2003.6, 25
3. Fang Lingyun, Wan Xinde, etc., dynamic analysis of water injection development of sandstone reservoirs. Beijing: Petroleum Industry Press, 1998
4. Liu Chunfa, et al. Successful practice of sandstone oilfield development. Beijing: Petroleum Industry Press, 1996
5. Liu Dingzeng, etc. Daqing Multi-layer Sandstone Oilfield Development. Beijing: Petroleum Industry Press, 1996