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The Flow Unit Division in the No.1 Fault Block of Pubei Oilfield

LIU Jiyu[a]; SHAO Shuai[a]; ZHAO Jiahong[b]; WANG Tianxu[b]

[a] Geoscience College of Northeast Petroleum University, Daqing, Heilongjiang, China.
[b] Jilin Oilfield Exploration and Development Institute, Songyuan, Jilin Province, China.
*Corresponding author.

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Abstract

The flow unit is a comprehensive reflection of reservoir's physical characteristics. Based on the basic characteristics of thin narrow sand reservoir, this paper has discussed geological factors which affects seepage characteristics and studied on the flow unit division methods of the thin narrow sand reservoir. Then, the flow unit in the objective layers was studied. The objective layers in the study area were divided into 26 vertical flow units. According to the analysis of coring well and other static data, the flow unit of objective layers in the coring well was divided into four types including Class Ⅰ, Class Ⅱ, Class Ⅲ and Class Ⅳ, whose classification standard was set up. For non-coring wells, the flow unit division is in accordance with the physical parameters of well logging interpretation. Finally, the distribution figures of plane flow unit in each sedimentary unit were drawn.

Key words: Thin narrow sand body; Flow unit; Seepage characteristic; Comprehensive quantitative assessment; Reservoir; Pubei oilfield

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INTRODUCTION

Located in the north of Songliao basin, the No.1 fault block of Pubei oilfield belongs to the Cretaceous 1st member of Yaojia Formation. The buried depth of the reservoir ranges from 800 to 1000 m. The reservoir in this fault block can be divided into three sandstone groups, eleven small layers and 26 sedimentary units. The reservoir mainly develops delta front facies subdivided into underwater distributary channel, main body sheet sand, non-main body sheet sand and lenticular sand. Lithological characteristic is mainly sand-shale interactive deposits dominated by silt to fine-grained sandstone, which is mainly composed of mud powder and fine sandstone with a small amount of fine sandstone, calcareous sandstone and siltstone deposition. With low permeability and thin narrow sand body, the reservoir has intermittent or stable strip flat form which is very apparent. The width is generally between 100 and 200 m. With small scale and scattered distribution, sand body is characterized by thin narrow sand body distribution.

The definition of reservoir flow unit was originally proposed by Hearn in 1984. The reservoir flow unit is defined as a reservoir belt which is continuous in the horizontal or vertical direction and has similar permeability, porosity and bedding features internally[1]. In this reservoir belt, the rock characteristics and geological parameters which affect flow unit are similar everywhere. Since then, the Chinese and foreign scholars have studied reservoir flow unit on the basis of the above definition. According to the geology and rock physical properties which affect fluid to flow in the rock, Ebank thought the flow unit is a further subdivided rock mass[2]. Amaefule thought the flow unit is a rock mass which has similar hydraulic characteristics in the given rock[3]. At the same time, domestic scholars also put forward some views. Qiu Yinan thought the flow unit refers to the flow channel formed naturally because the reservoir heterogeneity, spacer and inter porosity make the injected water along the geological structure displace oil in certain way[4]. Mu Longxin thought the flow unit is a sand body in which the reservoir unit has the same seepage characteristics caused by many factors such as boundary limitation, disccontinuous thin spacer layer, all kinds of sedimentary micro interfaces, small fault and different permeability[5]. The essence of the flow unit is the reservoir unit with the same seepage characteristics[6].

At present, scholars at home and abroad put forward different methods to identify and divide flow units[6~7]. For coring wells, flow unit identification and division rely on the core analysis data, which is called the single well recognition methods, including pore permeability method, pore throat structure parameter method, flow zone index method, pore throat radius method, comprehensive parameter method, outcrop depositional interface analysis method and analytic hierarchy process method (ahp). For the other wells, logging data which is very rich is used to identify and divide flow units, which is called multiple well recognition methods, including the seismic identification method, production dynamic parameter method and cluster analysis method.

Putaohua reservoir of the No.1 fault block in Pubei oilfield which was studied develops thin narrow sand body. However, the above methods can not well identify flow unit of thin narrow sand body. Therefore, this paper uses the combination method of qualitative and quantitative as well as the combination method of geological static data and production dynamic data to divide the flow units and evaluates the reservoir flow units comprehensively. It provides an effective way to know the reservoir hetero geneity, and has great significance to the secondary and tertiary oil recovery. Moreover, it is an effective method to improve the accuracy of reservoir description, determine the remaining oil distribution and improve development effect.

1. THE RESEARCH ON THE METHOD OF FLOW UNIT DIVISION

For the flow unit division, thin narrow sand body should be divided according to the geologic characteristics of thin narrow sand body and seepage features. The seepage characteristic difference is not only reflected in the vertical, but also reflected on the plane. Therefore, the flow unit division should consider not only the vertical seepage characteristics, but also the plane seepage characteristics to determine the spatial distribution of flow unit.

1.1 Vertical Division of Flow Units

The reservoir should be further subdivided according to the vertical seepage characteristic difference caused by the fault, fracture, interlayer and the rhythm of interlining, permeability, bedding structure and the distribution characteristics of pore structure. The subdivision degree depends on the research purpose and needs. In the study block, the vertical division of flow units in Putaohua reservoir has reached the present requirement and fully able to meet the needs of the flow units division in the vertical. Actually, the single sand layer and sedimentary unit were divided according to the definition of flow unit. For this reason, the vertical division of flow units in the research block is the same as the current subdivision of sedimentary units. Therefore, it is no need to be further subdivided and the current subdivision results of sedimentary units can be used as the vertical division results of flow units. The results are as follows (Table 1).

Table 1
Sedimentary/Flow Unit Subdivision Results in the Fault Block of Pubei Oilfield

	Sandstone groups	The sand group	Small layers	(flow) unit
PI	1-5	1-3	1	11
				12
			2	21
				22
				23
			3	31
				32
		4-5	4	41
				42
			5	51
				52
				53
	6-9	6-7	6	61
				62
			7	71
				72
		8-9	8	81
				82
			9	91
				92
	10-11	10-11	10	101
				102
				103
			11	111
				112
				113

1.2 The Flow Unit Classification

1.2.1 The Principle

Based on the selection of the reservoir flow unit parameters, the divison of reservoir flow unit classification can comprehensively evaluate multiple influential factors of reservoir flow units to get a comprehensive evaluation index finally, which can be used to classify the reservoir flow unit. The calculation equation of comprehensive evaluation index is[8]:

$$REI = \sum_{i=1}^{n} a_i X_i \qquad (1)$$

Type (1) ***REI*** - Comprehensive evaluation index of the reservoir flow unit;
X_i - Evaluation parameters of the reservoir flow unit;
a_i - Weight coefficient of evaluation parameters of reservoir flow unit;
n - The number of evaluation parameters of reservoir flow unit.

1.2.2 Flow Unit Classification of Coring Well

According to the actual data of coring well and the method of grey system theory, the flow units of PI reservoir in the No.1 fault block of Pubei oilfield can be divided. Grey correlation analysis method is to seek the main factors in the system to find out the important factors that affect the evaluation indexes, so as to grasp the main characteristics of things. Furthermore, the grey correlation analysis method includes many other steps such as the mother sequence and sequence selection as well as the calculation of correlation coefficient, correlation degree and weight coefficient[8].

According to the characters of the thin narrow sand body in the study area, the following parameters were selected as the division indexes of reservoir flow units: porosity, permeability, the sandstone thickness; effective thickness, net gross ratio, shale content and median grain diameter. In the the coring wells of study area, the calculation results of comprehensive evaluation index of reservoir flow units are shown in Table 2.

Table 2
The Flow Unit Classification Index Table

Layer number	The evaluation index	The flow unit types
PI 31	0.604	Ⅱ
PI 5_3	0.469	III
PI 6_2	0.826	Ⅰ
PI 7_2	0.63	Ⅱ
PI 9_2	0.743	Ⅰ
PI 10_2	0.591	Ⅱ
PI 10_3	0.792	Ⅰ
PI 11_1	0.425	Ⅳ
PI 11_3	0.335	Ⅳ

Combining the types of micro facies, the evaluation standard for flow unit classification was established by using grey correlation analysis method to calculate the division index of flow units and taking the average value of flow unit index of all micro facies (Table 3). According to the standard, the flow unit classification of coring well was divided and the results are shown in Table 2.

Table 3
Reservoir Flow Unit Classification Standards

Flow unit types	Classification index
Class Ⅰ	>0.65
Class Ⅱ	0.65～0.55
Class III	0.55～0.45
Class Ⅳ	≤0.45

Class Ⅰ reservoir flow unit is the best flow unit in the study area and mainly developes high permeability and high porosity reservoirs with large effective thickness, sandstone thickness and the net gross ratio. In Class Ⅰ, the sedimentary micro facies mainly include main channel sand body and main thick sand sheet.

In Class Ⅱ reservoir flow unit, the flow property is medium and the net is large. Class Ⅱ mainly developes middle permeability and middle porosity reservoirs with medium thickness and sandstone thickness. In Class Ⅱ, the sedimentary micro facies mainly include the shallow river and the main thin sand sheet.

With poor flow properties, Class Ⅲ reservoir flow unit mainly developes low permeability and porosity reservoir with small effective thickness, sandstone thickness and net gross ratio. In Class Ⅲ, the sedimentary micro facies mainly include the minor sand sheet and sheet sandstone lens.

Class Ⅳ reservoir flow unit has the poorest flow properties in the study area and mainly developes low permeability and porosity reservoir with small thickness, sandstone thickness and net gross ratio. In Class Ⅳ, the sedimentary micro facies mainly include distributary shallow, the minor thin sheet sand and distributary lenticular sand body.

1.2.3 The Flow Unit Classification of Non-Coring Wells

Under the condition of limited coring well data, physical parameters of monolayer in the non-coring well can be interpreted according to the rock electricity and well logging data. Based on interpretation data of physical parameters on each well, the flow unit of non-coring wells can be classified with the same method of coring wells, taking the following seven parameters: porosity, permeability, sandstone thickness, effective thickness, ratio net, shale content, median size as indexes.

1.3 Plane Flow Unit Division

According to the Equation (1), comprehensive evaluation indexes of plane flow unit in each sedimentary unit of all coring wells were calculated. Meanwhile, according to the flow unit classification standards, the plane flow unit types of each sedimentary unit were determined. For non-coring wells, the plane flow unit types of each sedimentary unit were divided in accordance with the physical parameters of logging interpretation. Finally, based on the plane types of flow unit in each sedimentary unit, the distribution figures of planar flow unit in each sedimentary unit were drawn (Figure 1, Figure 2).

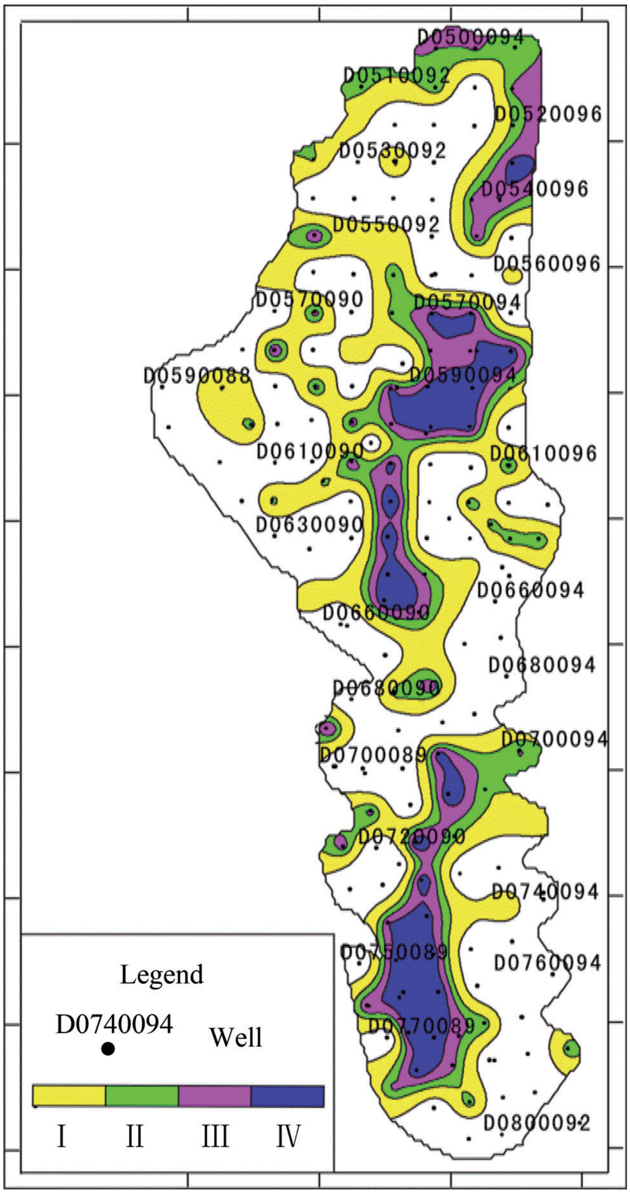

Figure 1
PI5$_2$ Flow Unit Distribution in Pubei Oilfield

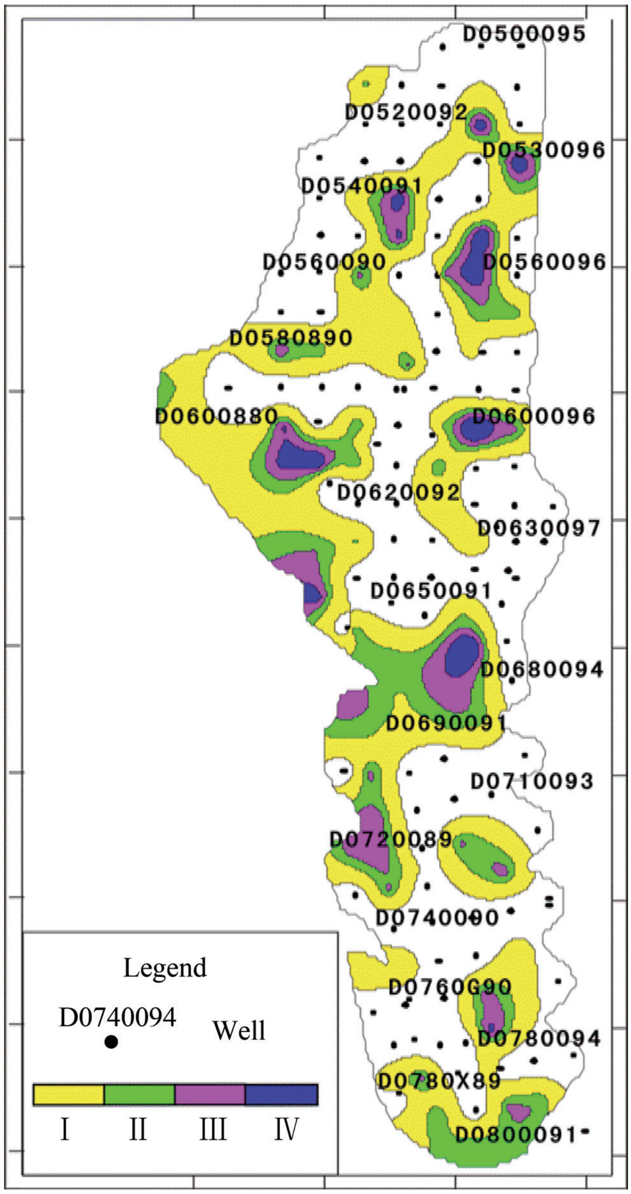

Figure 2
PI5$_3$ Flow Unit Distribution in Pubei Oilfield

In the Fault block of Pubei oilfield, the flow unit characteristics are as follows. In PI1$_2$ and PI1$_1$, the upper part of PI reservoir, the flow unit is mainly Class Ⅲ and Class Ⅳ. Being large contiguous or partially contiguous, the flow unit distribution is consistent with the distribution of sedimentary facies and generally presents the belt from north to south on the plane. In PI3$_2$, PI3$_1$, PI2$_3$, PI2$_2$ and PI2$_1$, the Class Ⅲ and Class Ⅳ flow units are still a lot, some local physical parameters are good to reach Class Ⅱ and Class Ⅰ flow unit can hardly be found. In PI5$_2$, PI5$_1$, PI4$_2$ and PI4$_1$, Class Ⅱ flow unit increases obviously and Class Ⅰ flow unit becomes more. In PI7$_1$, PI6$_2$ and PI6$_1$, Class Ⅰ and Class Ⅱ flow units increase significantly and the flow unit distribution presents the discontinuous belt mainly from north to south on the plane with partially contiguous distribution. In PI9$_1$, PI9$_2$, PI8$_2$ and PI8$_1$, Class Ⅰ and Class Ⅱ flow units begin to become less from PI8$_1$, PI8$_2$ to PI9$_1$, PI9$_2$, and at the same time, Class Ⅲ and Class Ⅳ flow units begin to increase largely. The sand body of flow unit presents stable belt on the plane and is partially contiguous. With few Class Ⅰ and Class Ⅱ flow units, PI10$_1$ and PI10$_2$ mainly have Class Ⅲ and Class Ⅳ flow units. The sand body of flow unit presents intermittent belt and unstable patchy distribution.the article mainly zonal sand and unstable patchy distribution. With the patchy or partially contiguous distribution, PI11$_3$, PI11$_2$, PI11$_1$ and PI10$_3$ mainly have Class Ⅳ flow units and a few Class Ⅲ flow units. Class Ⅰ and Class Ⅱ flow units decrease significantly.

CONCLUSIONS

(1) In the No.1 fault block of Pubei oilfield, PI reservoir group is divided into 26 vertical flow units, which is the same as present subdivided sedimentary unit.
(2) In the No.1 fault block of Pubei oilfield, the flow unit of PI reservoir group is divided into four types including Class Ⅰ, Class Ⅱ, Class Ⅲ and Class Ⅳ, whose classification standard are set up. Class Ⅰ is the best, Class Ⅱ is medium, Class Ⅲ is poor and Class Ⅳ is the poorest.
(3) The figures of plane flow unit distribution in each sedimentary unit were drawn. The plane flow unit distribution is greatly influenced by the distribution of sand body, mostly presenting the belt with partially contiguous distribution.
(4) Based on the characteristics of thin narrow sand body, the comprehensive evaluation method was put forward and has solved the disadvantages of single-factor classification evaluation that the evaluation result is not unique in the reservoir flow unit. It provides an efficient method to classify and evaluate the flow unit of thin narrow sand body correctly.

REFERENCES

[1] Hearn, C. L., Ebanks, W. J. Jr., Tye, R. S., *et al*. (1984). Geological Factors Influencing Reservoir Performance of the Hartwg Draw Field, Wgoming. *Journal of Petroleum Technology*, *36*(8), 1335-1344.

[2] Ebank, W. J. Jr. (1987). Flow Unit Concept-Integrated Approach to Reservoir Description for Engineering Projects. *AAPG Annual Meeting*, *AAPG Bulletin*, *71*(5), 551-552.

[3] Amaefule, J. O., & Altunbay, M. (1993). Enhanced Reservoir Description: Using Core and Log Data to Identify Hydraulic(Flow) Units and Predict Permeability in Uncored Intervals/Well. Presented at *the 68th Annual SPE Conference and Exhibition*, Oct. 2-5, Houston,Texas.

[4] Qiu, Y. N., & Wang, Z. B. (1996). *New Technology of Reservoir Description* (pp. 62-72). Beijing: Petroleum Industry Press.

[5] Mu, L. X., Huang, S. Y., & Jia, A. L. (1996). *New Technology of Reservoir Description* (pp. 1-10). Beijing: Petroleum Industry Press.

[6] Liu, J. Y., Wang, J. D., & Lv, J. (2002). Flow Unit Characteristics and Its Genetic Classification. *Geological Oil Experiment*, *24*(4), 381-384.

[7] Liu, J. Y., Feng, G. Q., Li, Q. L., & Feng, Y. C. (2009).The Flow Unit Study Review. Journal of Fault Block Oil and Gas Fields, *3*, 47-49.

[8] Liu, J. Y., Peng, Z. C., & Guo, X. B. (2005).Grey Correlation Analysis Method in the Application of Reservoir Evaluation - Illustrated by the Example of Oil Fields in the North II Area of Daqing Sartu. Petroleum Geology and Recovery Efficiency, *12*(2), 13-15.