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Study on In-Layer Heterogeneity of the Channel Single Sandstone Body in Each Facies Area of the Meandering River-Delta

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Abstract: There are three facies areas, that are meandering river, delta distributary plain and delta front in the reservoir layer of the BY region of the Daqing oilfield. SⅡ81、SII21、SⅢ8 are typical sedimentary time units which are respectively belong to each facies area. We Used statistic analysis method to obtain the subtle variety of the three permeability parameters- Kv, Tk and Jk- to make the research of the in-layer microfacies controlling heterogeneity of typical channel single sandstone body. Research indication: The in-layer heterogeneity of typical channel single sandstone body, the meandering river facies area's is relatively most serious, the distributary plain's is medium, and the delta front's is relatively weak.

Keywords: meandering-delta; typical sedimentary unit; interlayer; permeability; heterogeneity.

INTRODUCTION

In-layer heterogeneity is that vertical changes of reservoir characteristics in a single sandstone layer, which includes vertical permeability [1], grain size rhythm, difference degree of permeability [2, 3] and non-uniformity of interlayer distribution so on [4]. In-layer heterogeneity is the key factor which can directly control and affect a single sandstone layer's vertical thickness of water flooding and high or low efficiency of oil displacement. For this reason, writer takes typical sedimentary unit of deltaic inner front subfacies in the BY area block of Daqing oilfield as an example, to discuss distributions of the three permeability parameters: Kv, Tk and Jk. It is sound geological foundation for the acquaintance of remaining oil distribution of the Daqing oilfield.

EVALUATION PARAMETERS OF IN-LAYER HETEROGENEITY DEGREE OF PERMEABILITY

Permeability Variation Coefficient (Kv)

Kv is the ratio of standard deviation to mean value of permeability in a single sandstone layer reflects average value degree of samples deviation from the total [5-8]. Range of variation Kv≥0, the value is less small, the sample is more uniform. Generally, it is uniform when Kv≤0.5, express heterogeneous degree is leak. It is heterogeneous type when 0.5<Kv≤0.7, express the heterogeneous degree is moderate. It is no heterogeneous type when Kv>0.7, express the heterogeneous degree is serious.

$$K_V = \frac{\sqrt{\sum_{i=1}^{n}(K_i - \overline{K})^2/(n-1)}}{\overline{K}}$$

Permeability max/mean ratio (Tk)

Tk is the ratio of permeability max value (Kmax) to permeability mean value (Kmean). The range of variation Tk≥1, the smaller the value, the smaller the change of permeability in the vertical, the more good the heterogeneity. It is heterogeneous type when Tk<2, more heterogeneous when 3≥Tk≥2, it is un-heterogeneous type when Tk>3.

Tk＝Kmax/Kmean

Permeability max/min ratio (Jk)

Jk is the ratio of the max value to the min value of permeability. It reflects amplitude of variation of permeability. Its range of variation is Jk≥1, the bigger the value, the more serious the heterogeneity.

Jk＝Kmax/Kmin

Based on permeability data of the typical sedimentary time unit, the above 3 parameters were calculated and extracted. Then the facies-controlled plan contour maps of variation coefficient, max-mean ratio, max-min ratio of permeability of the sedimentary time unit were make. Finally, heterogeneous degrees of the time units were comparatively analyzed and researched.

IN-LAYER PERMEABILITY HETEROGENEITY RESEARCH OF THE THREE TYPICAL SEDIMENTARY UNITS

Regularity research of in-layer heterogeneity of typical sedimentary unit SⅡ81 in the meandering river facies area

Permeability Variation Coefficient (Kv): the distribution of peak value of the Kv of the typical sedimentary time unit is from 0.9 to 1.0. The main distribution is less than 0.2; it is account for 81%. The heterogeneity is weak; belong to heterogeneous type (Fig. 1a).

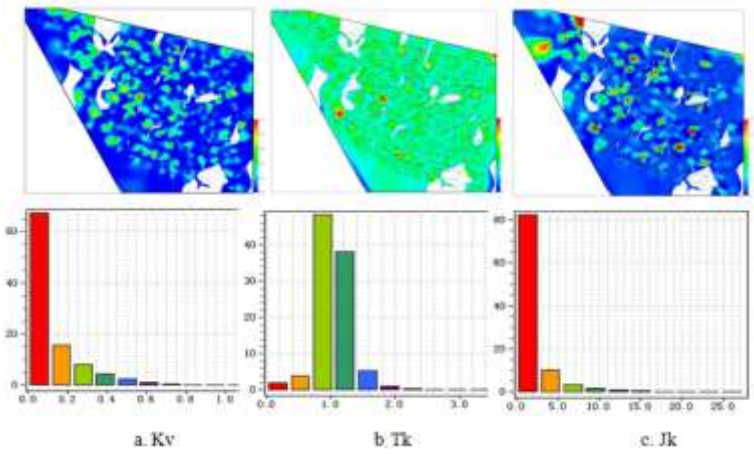

Fig. 1: Regularity of inlayer permeability heterogeneity parameters of the SII81

Permeability max-mean ratio (Tk): the main distribution range of the Tk is from 1.0 to 1.3, it is account for 82%. The heterogeneity is weak; belong to heterogeneous type (Fig. 1b).

Permeability max-min ratio (Jk): the main distribution of the Tk of the unit is less than 5. It is account for 84%. The heterogeneity is weak; belong to heterogeneous type (Fig. 1c).

Statistical data of the mentioned 3 parameters are synthesized to decide that the heterogeneity degree of permeability of the typical sedimentary time unit is weak, belong to heterogeneous type (Fig. 1)

Regularity research of in-layer heterogeneity of typical sedimentary unit SⅡ21 in the delta distributary plain facies area

Permeability Variation Coefficient (Kv): the distribution of peak value of the Kv of the typical sedimentary time unit is from 1.6 to 1.9. The main distribution is less than 0.35; it is account or 84%. The heterogeneity is weak; belong to heterogeneous type (Fig. 2a).

Permeability max-mean ratio (Tk): the main distribution range of the Tk is from 6.0 to 7.5, mainly distribution is 1.0-1.3, and it is account for 83%. The heterogeneity is weak; belong to heterogeneous type (Fig. 2b).

Permeability max-min ratio (Jk): the main distribution of the Tk of the unit is less than 8. It is account for 83%. The heterogeneity is weak; belong to heterogeneous type (Fig. 2c).

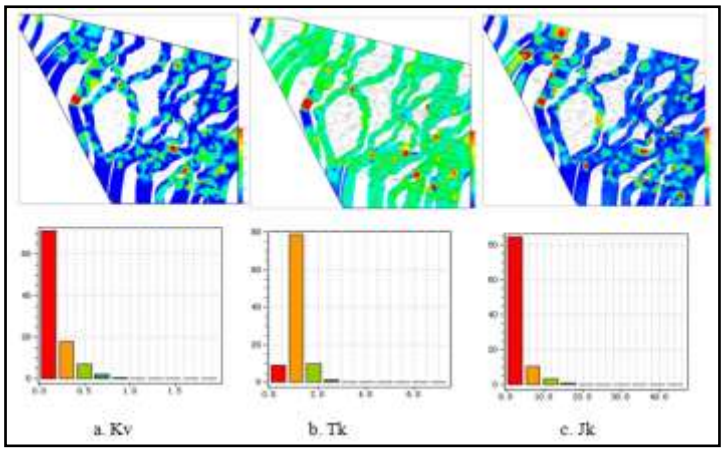

Fig. 2: Regularity of inlayer permeability heterogeneity parameters of the $SII2_1$

Statistical data of the mentioned 3 parameters are synthesized to decide that the heterogeneity degree of permeability of the typical sedimentary time unit is weak, belong to heterogeneous type (Fig. 2)

Regularity research of heterogeneity of typical sedimentary time unit in the deltaic inner front subfacies area

Permeability variation coefficient (Kv): the distribution of peak value of the Kv of the typical sedimentary time unit is from 0.86 to 1.05. The main distribution is less than 0.2; it is account for 66%. The heterogeneity is less weak; belong to heterogeneous type (Fig. 3a).

Permeability max-mean ratio (Tk): the distribution of peak value of the Tk of the time unit is from 2.8 to 3.6. The main distribution range is from 1.0 to 1.25, it is account for 80%. The heterogeneity is less weak; belong to heterogeneous type (Fig. 3b).

Permeability max-min ratio (Jk): the main distribution of the Tk of the unit is less than 6. It is account for 98%. The heterogeneity is less weak; belong to heterogeneous type (Fig. 3c).

Statistical data of the mentioned 3 parameters are synthesized to decide that the heterogeneity degree of permeability of the typical sedimentary time unit is less weak, belong to heterogeneous type (Fig. 3).

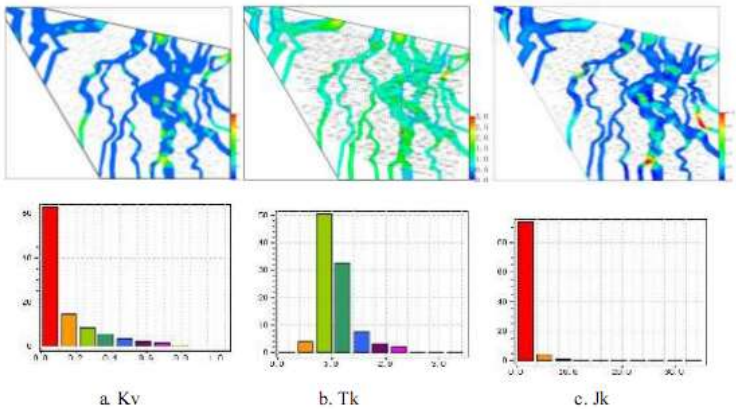

Fig. 3 Regularity of inlayer permeability heterogeneity parameters of the SⅢ8

ANALYSIS AND CONCLUSION

There are differences sedimentary features in the various sedimentary subfacies environment, therefore the in-layer heterogeneity degree of permeability are different.

Although the above research result is that the in-layer heterogeneity degrees of the three typical sedimentary units are weak, belong to heterogeneous type. When tabulate the parameters of the max, min, average values of Kv, Tk, Jk and synthetical coefficient (Table.1), we discovered the bellowing excellent regularity.

Using synthetical coefficient as a standard, the in-layer heterogeneity of permeability change regulation is gradually weak from meandering river to

delta distributary plain to deltaic inner front sedimentary area, i.e. The in-layer heterogeneity of typical channel single sandstone body, the meandering river facies area's is relatively most serious, the distributary plain's is medium, and the delta front's is relatively weak.

It is possible because the water dynamics condition variation was more strong when the meandering river of the flooding plain was deposited, the grain size and mud content also had very big change range, as a result, the heterogeneity degree of the permeability of the meandering rive was so serious.

Table1: Comparison of the heterogeneity parameters of each typical sedimentary time unit

facies area	layer name	average permeability (D)	Kv			Tk			Jk			synthetical coefficient
			min	max	ave	min	max	ave	min	max	ave	
meandering river	SⅡ8$_1$	0.668	0	1.12	0.11	1	3.49	1.05	1	27.4	2	0.231
	ave	0.646	0	1.39	0.15	1	3.9125	1.105	1	96.85	92.85	15.494
delta distributary plain	SⅡ2$_1$	0.471	0	1.97	0.15	1	7.36	1.13	1	46.4	2.5	0.424
	ave	0.544	0	1.38	0.14	1	4.51	1.121	1	63.69	2.69	0.458
delta inner front	SⅢ8	0.545	0	1.06	0.13	1	3.45	1.1	1	35.3	1.6	0.229
	ave	0.495	0	1.21	0.12	1	4.145	1.108	1	28.32	2.12	0.292

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