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Quantitative Relation of the Point BarWidth and Meander Belt Width of Subsurface Reservoir

YE Xiaoming[a],*; HUO Chunliang[a]; WANG Pengfei[a]; YANG Jianmin[a]; LI Junfei[a]

[a]Tianjin Branch of CNOOC Ltd., Tianjin, China.
*Corresponding author.

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Abstract

Due to large lateral oscillation amplitude, it tends to form complex meander belt in meandering river, which makes the internal sand body size and distribution characteristics of meandering river deposits in different region very complex. Subsurface reservoir architectural elements analysis based on the experience formula summarized from the outcrop and modern deposition research tends to have greater uncertainty. Microfacies sandbody size was measured through fine reservoir architecture research on mature area of target oilfield, it is concluded that meandering river microfacies sandbody scale is closely related to the size of the sedimentary system, the point bar width has the highest degree in related to meander belt width in the narrow banding patterns. Under different curvature, meandering river point bar length and width present a certain positive correlation, when the curvature is less than 1.7, the correlation is higher. The quantitative relation of different configuration unit of the target oilfield was established，it provided a quantitative basis for fine research and geological modeling on less well area of target oilfield and similar oilfield.

Key words: Meandering river; Point bar width; Meander belt width; Subsurface reservoir; Quantitative relation

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INTRODUCTION

Since Miall put forward the concept and method of reservoir configuration since 1985[1], the sand body internal configuration study has become a research focus in the oil industry[2], in which meandering river has been studied most with abundant achievements. At present, lots of meandering river reservoir qualitative and quantitative model were established through outcrop and modern deposition, flume experiment[3-4], which guided the meandering river reservoir fine configuration of many old oilfields, it has played a great effect in the process of oilfield comprehensive adjustment and remaining oil potential[5]. But as is known to all, due to large lateral oscillation amplitude, it tends to form complex meander belt in meandering river, which makes the internal sand body size and distribution characteristics of meandering river deposits in different region very complex.

In the process of actual oil field research, there are many differences in the distribution range and plane distribution characteristics of the meandering river sand body of different layers, subsurface reservoir architectural elements analysis based on the experience formula summarized from the outcrop and modern deposition research tend to have greater uncertainty. Therefore, it is necessary to carry out the detailed anatomy of the mature oilfield to establish the quantitative relationship between configuration unit, which can provide a quantitative basis for fine research and geological modeling on less well area of target oilfield and similar oilfield.

1. RESEARCH METHODS AND DATA SOURCES

Due to the complexity of a meandering river and limited research data of underground reservoir, the geometric parameters of the underground reservoir could not be directly measured as outcrop and modern deposition, especially for lateral accretion body and lateral accretion sandwich of point bar sand body. So this paper was mainly aimed at four to five grade configuration unit, the quantitative relationship of single meander belt and single point bar was studied. At first, compound sandbody was divided into single sandbody with the actual field data under the guidance of the existing model, then single microfacies sandbody size was measured, the quantitative relationship between the main configuration was analysised unit lastly.

Q oilfield in bohai sea area was studied as an example in this paper, microfacies sandbody reservoir geologic knowledge database was established by fully using of high resolution seismic data in offshore oil field and a large number of horizontal well data under the guidance of the existing model. Firstly, single well sedimentary microfacies was quantitative identificated by log curve, sand body boundary was depicted by comprehensive application of well and seismic data, plane microfacies map of each layer were compiled combining with sand body thickness distribution and single well microfacies. Then measurement and statistics of microfacies sandbody size of each layer were done based on the plane microfacies map. Lastly, classified statistical data analysis was done to get the quantitative relationship between different grades configuration unit.

Q oilfield is a large meandering river oilfield located in the central bohai sea, Lower Minghuazhen Formation is the major hydrocarbon containing target zone. This study mainly discussesed the typical layer of Minghuazhen Formation, single meander belt width, point bar width and length, point bar arc length and other parameters were measured. The specific meaning of the parameters is shown in Figure 1.

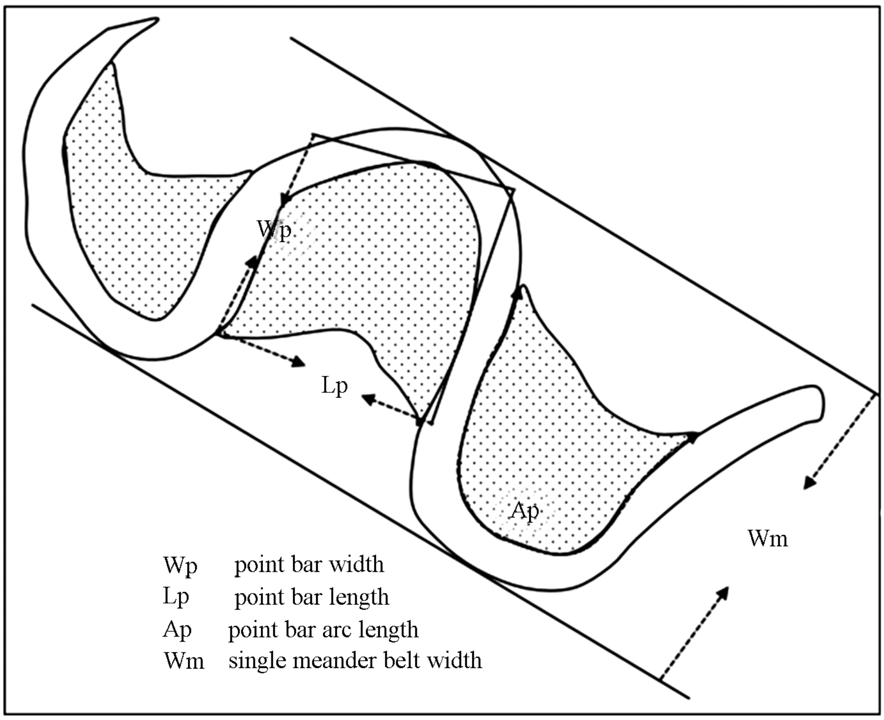
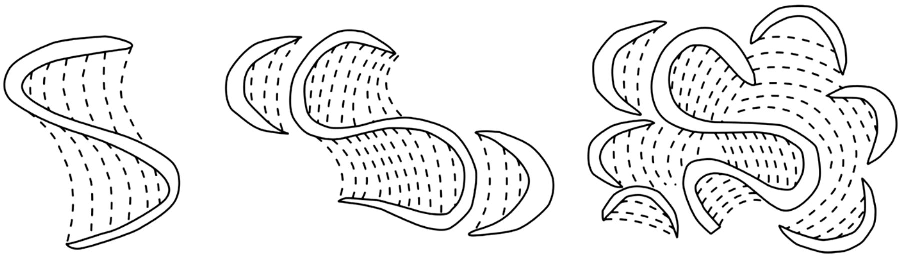


Figure 1
Schematic Diagram of Parameter Measurement

2. DATA STATISTICS AND THE QUANTITATIVE RELATIONS ANALYSIS

Based on the plane microfacies map of each layer, the meandering river reservoir of Q oilfield was divided into 3 types by point bar plane distribution pattern (Figure 2), they are narrow strip meandering river, wide strip meandering river and scalelike meandering river. Narrow strip meandering river is mainly consist of independent distributed single abandoned channel and single point bar adjoined to abandoned channel. Wide strip meandering river is mainly consist of compound point bar formed by the oscillation of 2 to 4 abandoned channels. Scalelike meandering river is mainly consist of large area distributed compound point bar formed by the oscillation of many channels. Data statistics and analysis for 3 layers of Q oilfield was done for this study, in which Ⅲ-2 layer belongs to narrow strip meandering river, Ⅰ-3-1 layer belongs to wide strip meandering river and Ⅱ-3 layer belongs to scalelike meandering river.



(a) Narrow strip (b) Wide strip (c) Scalelike

Figure 2
Point Bar Plane Distribution

2.1 Data Measurement and Statistic

Firstly, each independent distributed microfacies unit was numbered on each plane microfacies distribution map. Then the geometric parameters such as length and width of each unit were measured. Single meander belt width, point bar width and length, point bar arc length and other parameters were mainly measured for this paper. Table 1, Table 2 and Table 3 are the final measurement result data tables of 3 typical layers in Q oilfield, in which the curvature is a calculation result of measurement data, its value is equal to point bar length divided by point bar arc length.

Table 1
Parameter Table of Wide Strip Meandering River

Layer	Point bar number	Channel width /m	Point bar length /m	Meander belt width/m	Point bar width /m	point bar arc length/m	Curvature
Ⅰ3-1	1	92.9	164.1	881.2	496.9	1326.9	8.09
	2	82.2	370.7	781.6	591.3	1515.9	4.09
	3	61.7	600.8	647.7	433.1	1234.9	2.06
	4	61.4	291.3	469.6	309.1	917.3	3.15
	5	67.2	451.2	627.1	296.5	846.8	1.88
	6	57.9	408.2	721.9	445.0	1231.5	3.02
	7	56.0	476.6	541.0	347.5	1124.4	2.36
	8	52.3	671.7	787.7	382.0	1252.2	1.86
	9	68.7	801.2	962.6	557.1	1791.3	2.24
	10	58.4	532.5	782.3	526.3	1353.4	2.54
	11	57.7	576.6	722.9	321.3	1093.9	1.90
	12	61.4	537.2	520.5	218.6	839.2	1.56
	13	64.8	920.2	437.4	170.3	1026.7	1.12
	14	93.8	1396.4	890.7	553.9	1977.9	1.42
	15	59.3	893.1	642.3	381.4	1329.2	1.49
	16	70.1	487.1	560.4	282.1	924.2	1.90
	17	52.3	704.7	1059.6	660.2	1693.4	2.40
	18	71.1	900.7	1020.8	461.7	1524.1	1.69
	19	58.5	735.1	1041.3	510.2	1502.7	2.04
	20	39.2	507.6	596.2	363.6	1013.5	2.00
	21	65.4	679.4	402.1	178.4	892.7	1.31
	22	75.6	748.1	728.8	376.6	1290.2	1.72
	23	69.5	927.7	850.9	364.7	1276.7	1.38
	24	54.4	515.6	1059.1	560.5	1475.1	2.86
	25	65.2	1526.3	750.5	450.6	1872.5	1.23
	26	48.7	882.3	814.5	476.9	1664.7	1.89
	27	61.9	971.6	776.6	380.9	1324.6	1.36
	28	74.9	566.3	1031.6	431.8	1313.7	2.32
	29	50.7	1035.5	906.4	505.1	1634.7	1.58
	30	61.6	750.2	759.8	393.1	1272.8	1.70
	31	68.2	400.5	451.1	172.4	634.7	1.58
	32	55.5	703.5	778.9	226.6	939.1	1.33
	33	49.5	521.4	660.3	401.7	1123.1	2.15
	34	54.3	373.5	246.1	107.7	518.4	1.39

Table 2
Parameter Table of Scalelike Meandering River

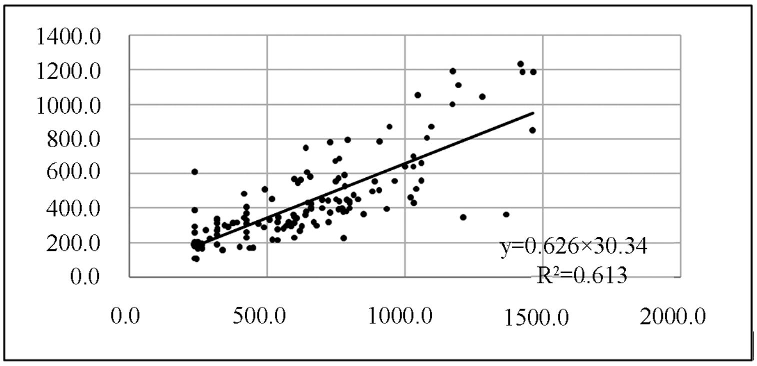
Layer	Point bar number	Channel width /m	Point bar length /m	Meander belt width/m	Point bar width /m	Point bar arc length/m	Curvature
	1	57.7	738.4	1464.7	1184.0	2798.5	3.79
	2	53.6	1461.6	1279.7	1043.2	2883.1	1.97
	3	69.1	1793.8	1462.0	849.1	2552.8	1.42
	4	61.0	983.1	1425.5	1185.5	2943.1	2.99
	5	61.3	914.7	762.2	438.9	1961.6	2.14
	6	62.5	1171.1	1171.5	998.7	2596.7	2.22
	7	59.3	962.7	1211.2	348.3	1260.6	1.31
	8	67.8	851.8	729.5	781.5	2004.6	2.35
	9	62.3	768.3	608.7	344.5	1083.8	1.41
	10	83.7	553.4	510.8	334.2	1125.4	2.03
	11	77.3	663.8	540.0	216.9	886.5	1.34
	12	55.9	863.9	661.8	395.8	1301.8	1.51
	13	61.4	974.6	612.9	545.5	1595.8	1.64
	14	65.2	1444.3	793.2	793.2	2240.4	1.55
	15	65.2	1179.3	1193.3	1109.1	3183.9	2.70
	16	66.7	858.5	1418.1	1231.4	2880.5	3.36
	17	73.3	1260.7	1365.5	363.7	1425.4	1.13
	18	41.2	692.7	279.8	274.8	956.6	1.38
	19	67.8	912.3	359.8	293.3	1306.4	1.43
	20	66.5	1268.3	907.6	783.3	2104.6	1.66
II 3	21	65.2	1511.9	622.1	562.7	1956.4	1.29
	22	68.1	1711.6	748.1	671.4	2200.7	1.29
	23	68.1	1585.4	762.4	685.6	2180.4	1.38
	24	86.2	1130.1	1095.6	869.1	2197.4	1.94
	25	67.8	1099.8	657.6	583.0	1741.0	1.58
	26	58.3	1051.0	492.5	508.4	1719.4	1.64
	27	54.2	782.8	321.6	282.1	1071.6	1.37
	28	50.9	660.4	518.6	454.4	1354.3	2.05
	29	61.0	834.0	771.8	400.5	1250.6	1.50
	30	78.0	893.4	376.1	313.4	1215.1	1.36
	31	44.2	968.7	944.5	869.4	2142.0	2.21
	32	63.9	732.3	1079.9	805.3	2054.0	2.80
	33	74.4	1347.5	598.9	568.0	1936.4	1.44
	34	68.6	1152.7	641.7	747.5	2088.1	1.81
	35	57.9	945.0	645.9	607.0	1761.7	1.86
	36	54.6	912.4	347.6	302.0	1212.1	1.33
	37	57.7	1210.4	1173.8	1189.4	3054.6	2.52
	38	51.8	848.8	588.1	298.1	1283.6	1.51
	39	71.9	1062.9	1045.6	1050.1	2721.3	2.56
	40	48.9	868.7	934.5	395.4	1361.0	1.57

Table 3
Parameter Table of Narrow Strip Meandering River

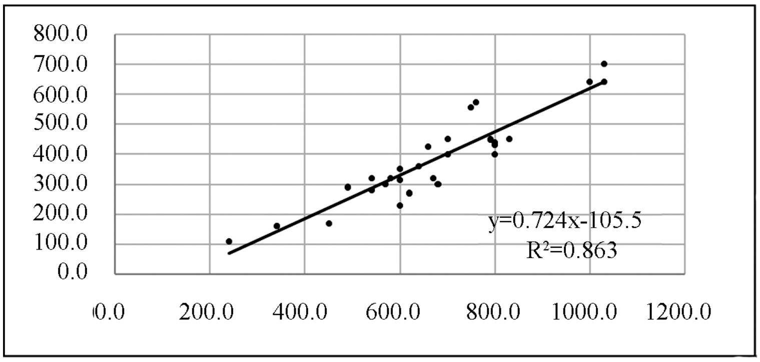
Layer	Point bar number	Channel width /m	Point bar length /m	Meander belt width/m	Point bar width /m	Point bar arc length/m	Curvature
	1	52.0	367.0	800.0	431.0	1053.0	2.87
	2	56.0	649.0	830.0	451.0	1525.0	2.35
	3	65.0	536.0	660.0	426.0	1100.0	2.05
	4	60.0	424.0	790.0	449.0	1520.0	3.58
	5	61.0	878.0	760.0	573.0	1600.0	1.82
	6	60.0	649.0	750.0	555.0	1480.0	2.28
	7	60.0	580.0	640.0	360.0	1110.0	1.91
	8	60.0	740.0	800.0	440.0	1260.0	1.70
	9	60.0	840.0	800.0	400.0	1350.0	1.61
	10	70.0	640.0	540.0	320.0	1050.0	1.64
	11	64.0	560.0	570.0	300.0	1030.0	1.84
	12	54.0	270.0	670.0	320.0	840.0	3.11
	13	60.0	580.0	600.0	315.0	1101.0	1.90
	14	60.0	460.0	340.0	160.0	600.0	1.30
III-2	15	60.0	655.0	620.0	270.0	1010.0	1.54
	16	60.0	520.0	600.0	230.0	840.0	1.62
	17	60.0	860.0	600.0	350.0	1240.0	1.44
	18	60.0	830.0	700.0	450.0	1480.0	1.78
	19	60.0	550.0	240.0	110.0	630.0	1.15
	20	60.0	920.0	450.0	170.0	980.0	1.07
	21	62.0	720.0	700.0	400.0	1350.0	1.88
	22	66.0	960.0	580.0	320.0	1280.0	1.33
	23	50.0	660.0	540.0	280.0	1080.0	1.64
	24	68.0	590.0	680.0	300.0	1140.0	1.93
	25	80.0	490.0	340.0	160.0	710.0	1.45
	26	60.0	570.0	490.0	290.0	700.0	1.23
	27	70.0	960.0	1030.0	700.0	1990.0	2.07
	28	80.0	760.0	1000.0	640.0	1910.0	2.51
	29	75.0	740.0	1030.0	640.0	1750.0	2.36

2.2 Quantitative Relation of the Point Bar Width and Meander Belt Width

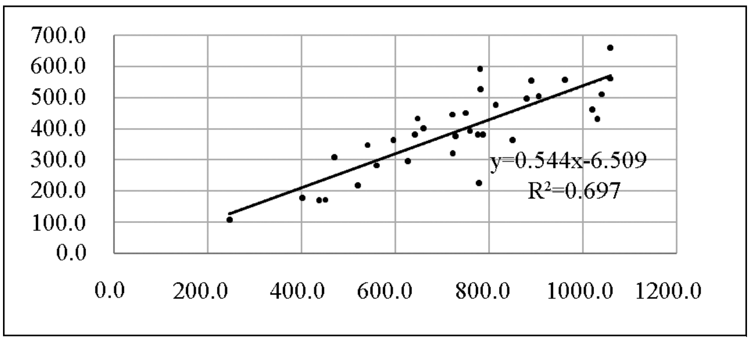
Firstly, quantitative relation of the point bar width and meander belt width was studied by using all data of the 3 layers in Q oilfield, the result is shown in Figure 3(a), the correlation coefficient is 0.6137, the correlation formula is: y=0.6263x+30.342, in which x is meander belt width, y is point bar width, the unit is meter. The results show that there is a certain positive correlation between the point bar width and meander belt width, but the correlation coefficient is not high. So the quantitative relation was reanalyzed according to the three different types of the meandering river. The narrow strip meandering river fitting results is shown in Figure 3(b), wide strip meandering river fitting results is shown in Figure 3(c), scalelike meandering river fitting results is shown in Figure 3(d). The results show that there is a certain positive correlation between the point bar width and meander belt width of different meandering river types, but the correlation formula is different in different types. The correlation coefficient of narrow strip meandering river is the highest with the value of 0.8635, wide strip meandering river is the medium with the value of 0.6977, and scalelike meandering river is the lowest with the value of 0.5732.



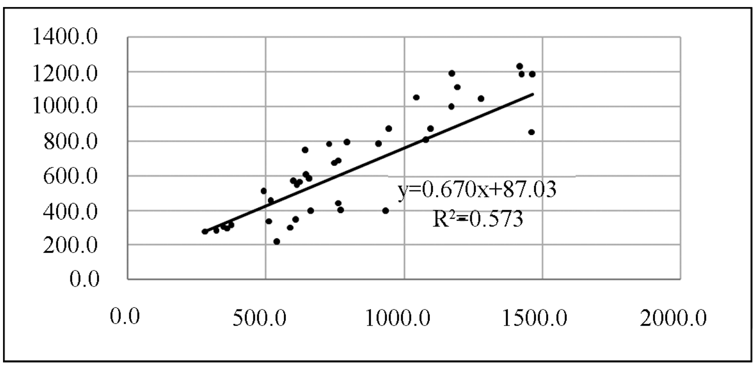
(a) All data



(b) Narrow strip meandering river



(c) Wide strip meandering river



(d) Scalelike meandering river

Figure 3
Quantitative Relation of the Point-Bar Width and Meander Belt Width

2.3 Quantitative Relation of the Point Bar Length and Point Bar Width

Firstly, quantitative relation of the point bar length and point bar width was studied by using all data of the 3 layers in Q oilfield, the result is shown in Figure 4 with the black solid line. The result shows that the correlation is poor, the correlation coefficient is only 0.2986. In order to study the quantitative relation of the point bar length and point bar width under different curvature, all the measured data were divided into two classes according to the curvature. The curvature less than 1.7 was divided into low sinuosity meandering river, the curvature greater than or equal to 1.7 was divided into high sinuosity meandering river, then the quantitative relation was researched separately, the result is shown in Figure 4 with the black dotted line above the black solid line represents the curvature is greater than or equal to 1.7, black dotted line below the black solid line represents the curvature is less than 1.7.

The results show that there is a certain positive correlation between the point bar length and point bar width under different curvature. The correlation coefficient is higher with the value of 0.7231 when the curvature is less than 1.7. When the curvature is greater than or equal to 1.7, the correlation coefficient reduced to 0.5583, but it has improved greatly than previous research by using all data of the 3 layers.

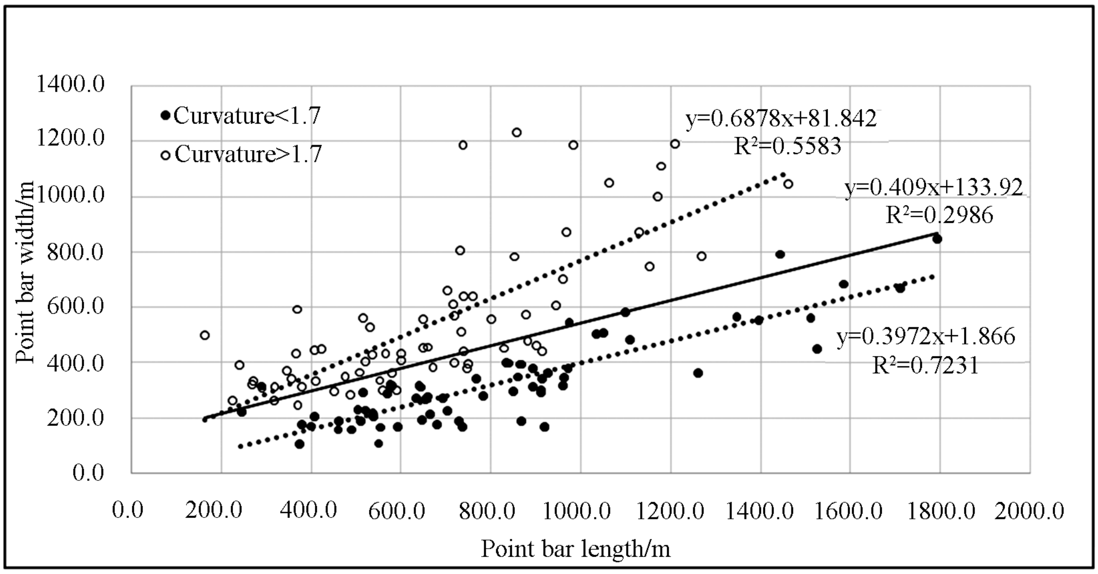


Figure 4
Quantitative Relation of the Point-Bar Length and Point-Bar Width

3. APPLICATION DISCUSSES

The statistical calculation of microfacies sand body geometry parameters provides a good basis for the selection of reservoir modeling method and parameters. The microfacies sand body geometry parameters can be directly used as input data to constrain the establishment of the microfacies model when object based model method is adopted, it also can improve the accuracy of fitting variogram when the model method based on pixel is adopted. When multiple-point geostatistics method is adopted to build microfacies model, train images can be built up under the guidance of research results.

Through the study on quantitative relation of the point bar width and meander belt width, it is concluded that microfacies sandbody scale of meandering river is closely related to the size of the sedimentary system, there is a certain positive correlation between them, but the related degree of different types is not the same. The correlation coefficient of narrow strip meandering river is the highest, wide strip meandering river is the medium and scalelike meandering river is the lowest. The results show that with point bar plane distribution pattern is more and more complex, the correlation between point bar width and meander belt width reduced accordingly. In the process of practical application, different correlation formula should be adopted based on the microfacies sand body distribution shape. Meandering river reservoir in offshore oilfield generally buried shallower with a high resolution seismic data, by utilizing the regression formula of this paper, single point bar width could be roughly calculated on the basis of single meander belt be identified by seismic data. And the results of narrow strip meandering river have the highest credibility.

CONCLUSION

(a) There is a certain positive correlation between the point bar width and meander belt width of different meandering river types, but the correlation formula is different in different types. The correlation coefficient of narrow strip meandering river is the highest, wide strip meandering river is the medium and scalelike meandering river is the lowest. Due to large lateral oscillation amplitude, it tends to form complex meander belt in meandering river, How to identify the single channel from complex meander belt is the key of the underground reservoir characterization. By utilizing the regression formula of this paper, single point bar width could be roughly calculated on the basis of single meander belt be identified by seismic data. And the results of narrow strip meandering river have the highest credibility.

(b) There is a certain positive correlation between the point bar length and point bar width under different curvature. The correlation coefficient is higher when the curvature is less than 1.7. When the curvature is greater than or equal to 1.7, the correlation coefficient is relative lower.

(c) Due to the complexity of meandering river and the possible error existing in the statistical process, the correlation of part geometric parameters is not high, it is needed to carry out further research.

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