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Study on the physical parameters interpretation of the H reservoir in W oilfield

He Wei[1],Ma shizhong[1],Wang Hao[1],Wang Zhao[2],Yan Xu[2], Zhu Yu[2]

(1. Earth Science of Northeast Petroleum University, Daqing 163318，P.R.China
2. China Petroleum Daqing Oilfield Limited Company, Daqing 163000，P.R.China)

Abstract: The H reservoir in W oilfield belongs to delta front deposition and it is formed by the impact of both geological forces of the rivers and waves. The reservoir is strongly transformed in the later stage. Therefore, it formed the scattered sand body, obvious heterogeneity, complex fluid distribution, causing that the original parameter interpretation method can not accurately characterize the regularity of the target area. For this problem, this paper use original data of drill core, well logging and oil testing as base, doing the research of curve standardization, principal component analysis and parameter optimization in target area, respectively established porosity interpretation model which based on muddy correction, compaction correction and sedimentary facies correction and permeability interpretation model which based on the type of sedimentary facies, summarizing the physical characteristics and the conclusion is drawn that the target area is low porosity and ultra-low permeabilite reservoir characteristics. Therefore, this paper not only provides the basis for the development of target area, but also provides an effective method for the interpretation of the physical parameters of complex reservoirs.

Keywords*: - Petrophysical parameters; Principal component analysis; Parameter optimization; Interpretation model*

I. INTRODUCTION

With the rapid development of the exploration technology in oil-field, more and more complex oil and gas field has become the main target of exploration and development. The H oil-field W reservoir in this paper, due to the scattered distribution of sand body, the complex oil and water distribution, the rapid changing of the sedimentary facies, the similar vertical environment, multi fault and incline shaft, large area and well spacing, it is difficult to explain the physical parameters. Therefore, this paper, through a large number of core data, well logging, logging and testing data ,analysis and determine the target zone lithology-electric property relation, to carry out the core normalization, deviation correction, standard curve and principal component analysis, parameter optimization.And on this basis, to establish the mud correction, compaction correction, sedimentary facies correction of porosity interpretation model and permeability interpretation model, finishing physical parameters interpretation of the 310 wells in the target zone of reservoirs, and ultimately achieving high matching degree, providing a reliable basis for the study of the subsurface geology rules.

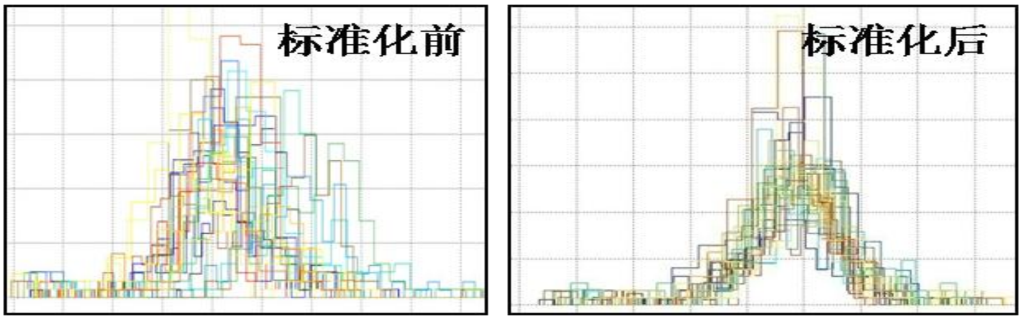
II. HEADINGS

2. Data preprocessing

In order to improve the accuracy and reliability of interpretation results, the range of the well logging curves, the depth of core sample points must be accurate. Interpretation of logging data by computer is mainly based on the continuous depth point, calculate every sample point by equidistant. Therefore, it is necessary to make correction and homing on the curve, core data, well deviation. In addition, it should take logging series of each well, unified of the unit and difference of the range into consideration. And finally, the accuracy of the data is ensured by the method of the curve standardization and the principal component analysis.

2. 1 Loging preprocessing

According to the results of lithology interpretation and the characteristics of each curve, the relationship between the rock and the electricity is determined. In the mean time, the type of the logging which can reflect the characteristics of the reservoir physical property is determined by the method of principal component analysis. Because of the well logging series, unit scale, sampling interval, difference of the scale, it should standardize each curve firstly. Moreover, finishing the principal component analysis to reduce the error between curves. This research mainly uses the method of histogram standard. Figure 1 is the comparison before and after curve standardization. As shown, due to the influence of the factors such as well logging tools, calibration, and logging time, the difference of the acoustic curve is relatively large before and after standardization. If such data is used in processing of interpretation, there will be a lot of error, it may even lead to a wrong conclusion.After the standardization, it can be said that the distribution of curve is basically accord with normal distribution.



Before After

Fig.1 Comparison of standard before and after

The correlation coefficient between the standardization curve is calculated. According to the correlation coefficient matrix, the characteristic value λ is calculated. Further, calculating the principal component contribution rate and the cumulative contribution rate, therefore, the types of log curve is selected. Tab.1 shows coefficient of curve about the first principal component and the second component based on this research. By formula (1) and (2) , the total contribution rate of the first principal component(P1) and the second component(P2) is 84.426%.

Principal component contribution rate:

$$P_1 = \lambda_i \Big/ \sum_{j=1}^{n} \lambda_j, i = 1,2\cdots, n \quad (1)$$

Cumulative contribution rate:

$$P_2 = \sum_{j=1}^{i} \lambda_j \Big/ \sum_{j=1}^{n} \lambda_j, i = 1,2\cdots, n \quad (2)$$

Tab.1 Coefficient of curve

The type of curve	coefficient	
	the first principal component	the second component
GR	-0.703	0.542
RLLD	0.994	0.107

RLLS	0.979	0.112
SP	-0.751	0.204
AC	-0.783	-0.453
RMN	0.862	0.374
RMG	0.873	0.383
RMSL	0.752	0.360

From the tab.1, the first and the second principal component coefficients of each curve are different.There is a mutual expression between partial curves. In this research, the author take the physical model into consideration, simplify operation, the curves of GR, AC, RLLD and RMG were chosen as the curve set of the physical interpretation model by the results of principal component analysis.

2. 2 The depth homing of core data

Because the depth of core comes from the drilling depth, the depth from the drilling and the logging cable are derived from two different systems. Therefore, the depth of coring data and logging depth is different, it is necessary to make depth homing for coring data. In the mean time, core location is the basis to explain the physical parameters. It's precision directly determine the accuracy of the physical interpretation model. At present, core location are based on the trend of the curve and core samples to determine, it still can not achieve the accuracy of a few centimetres. The depth of the homing coring data mainly controlled by the corresponding relationship between the lithology and electrical property and GR, AC, RLLD in the strict and RLLS curves.

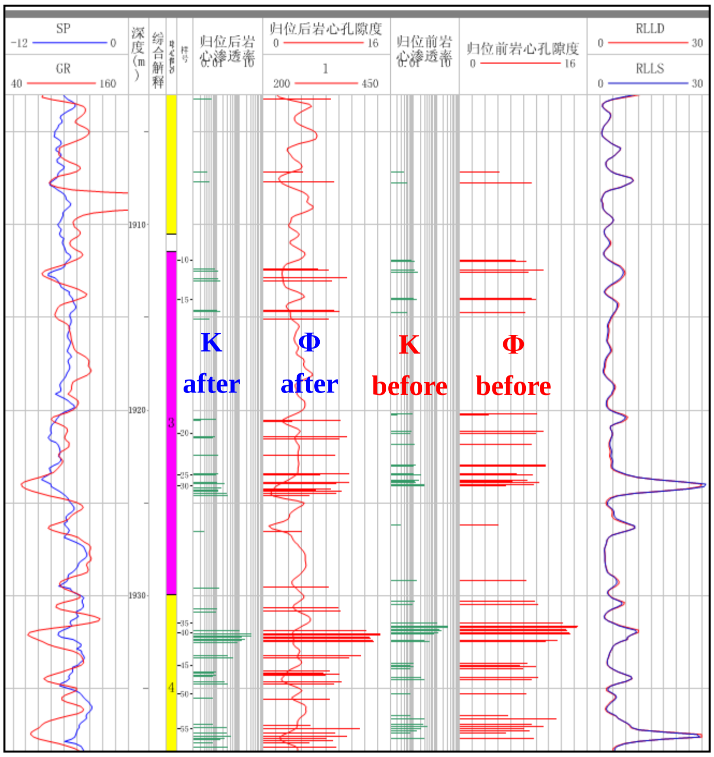


Fig.2 Comparison of the coring data before location and after before and after in a well

III. THE ESTABLISHMENT OF PHYSICAL PARAMETER INTERPRETATION MODEL

3. 1 Calculation of the shale content

In reservoir evaluation, there are so many parameters which can effect physical property of reservoir. The shale (Vsh) content in reservoir not only can reflect the lithology, but also can impact porosity, permeability, effective pore size and so on. Therefore, it is necessary to make shale correction by calculating shale content in the process of interpretation. In the meantime, the calculation of the shale content is mainly based on rock mass model, according to combination of the logging response and core data. There is no radioactive mineral within study area and GR is a curve that mainly reflects the adsorption degree of mud in the formation. So, it always introduce GR curve to make shale correction. It can calculate by the formula (3).

$$\Delta GR = \frac{GR - GR_{\min}}{GR_{\max} - GR_{\min}} \qquad V_{sh} = \frac{2^{G_{CUR} * \Delta GR} - 1}{2^{G_{CUR}} - 1} \tag{3}$$

In which: V_{sh} is the shale correction; ΔGR is relative value for GR; GR is the value of curve; the definition of the $GR_{\min}$ and $GR_{\max}$ see below。

Taking all physical parameters interpretation formula into account, reading value is the most critical work.Its standard directly determines the accuracy of interpretation results.The following two criteria of the $GR_{\min}$ and $GR_{\max}$ are presented in follow.

①The reading value of $GR_{\max}$ is the gamma value of the shale layer which is relatively stable in the target layer.

②The reading value of $GR_{\min}$: first, preferring to read the gamma value of pure sandstone; second, if $GR_{\min}$ is caused by the reason of calcareous interlayer, its need to read value again that the pure sandstone section reflected.

3. 2 Porosity interpretation model

After multiple studies on the model of physical interpretation in target areas, this paper not only introduce the shale correction factor, but also introduce the Wylie formula with compaction correction. As is known to all, the cost of the compensation density logging and compensated neutron logging are higher, therefore, it is not common in most oil fields. However, the AC curve is very common. Almost all of the well have this kind of curve. So it is very important to use the AC curve to establish the model.

When the AC curve is introduced to establish the porosity interpretation model, taking into account the depth of the oil layer in the target area, 1700 meters, the reservoir porosity is mainly affected by compaction. Therefore, the physical interpretation of the model selected the effective porosity interpretation model with the compaction correction. After screening, the porosity interpretation model of the target area is obtained.

$$\phi = \frac{(AC - AC_{ma})}{(AC_f - AC_{ma}) * CMP} - C_1 * V_{sh} * \frac{(AC_{sh} - AC_{ma})}{(AC_f - AC_{ma})} + k_1 \tag{4}$$

In which: ϕ is the porosity; AC is a curve after the preprocessing; AC_{ma} is the AC value for rock skeleton; AC_{sh} is the AC value For mudstone ; AC_f is AC value for fluid in formation; V_{sh} is the shale content correction factor; CMP is the compaction correction factor, which is obtained by fitting; C_1 、 k_1 is the coefficient by the regression fitting, the dimensionless.

In the target area, 41 wells, 1726 core data points were used to carry out regression fitting, the actual porosity interpretation model formula. On the premise of the confidentiality, it doesn't disclose the actual fitting formula, just the model is shown.

In addition, the reservoir physical properties are still mainly affected by the deposition, so in this paper, it presents a new type of porosity correction factor which is based on type of sedimentary facies.Based on the micro facies classification, the difference of the physical properties of different phases was calculated, and the porosity correction factors of each phase were calculated. The specific algorithm is, according to the interpretation of the model formula (4) to calculate the porosity of the core sample point. Furthermore, according to the type of microfacies, calculating the average porosity of each microfacies of the core. Finally, calculating the difference between the porosity by formula(4) and porosity by core measurement, the reference value of the porosity correction factor was determined, and then the porosity correction factor of each microfacis was calculated.

Tab.2 Porosity correction based on micro facies type combined with sandstone thickness

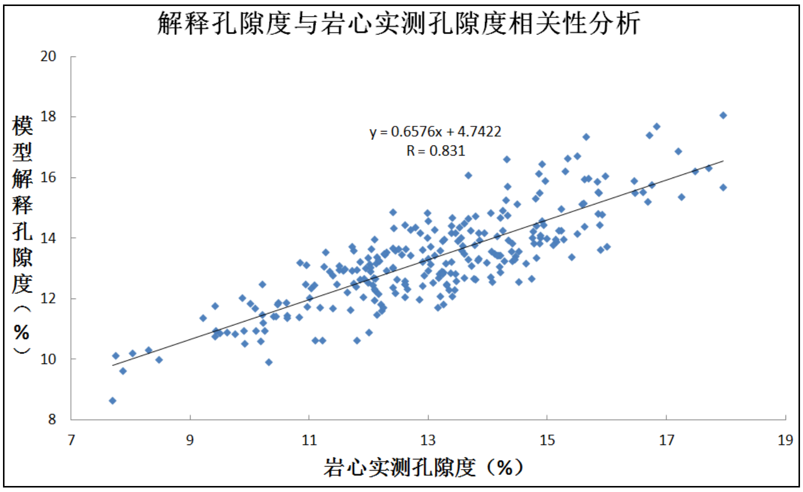
Type of sedimentary facies	Average porosity	Porosity correction based on micro facies type combined with sandstone thickness
Underwater distributary channel	14.462	1.103
Main sheet sand in inner front	13.575	0.512
Non main sheet sand in front	12.759	0.146
main sheet sand in outer front	12.451	-0.308
Non main sheet sand	10.096	-0.963

In the case of considering the influence of many factors, the finally porosity interpretation formula of the target area is determined by the above research.

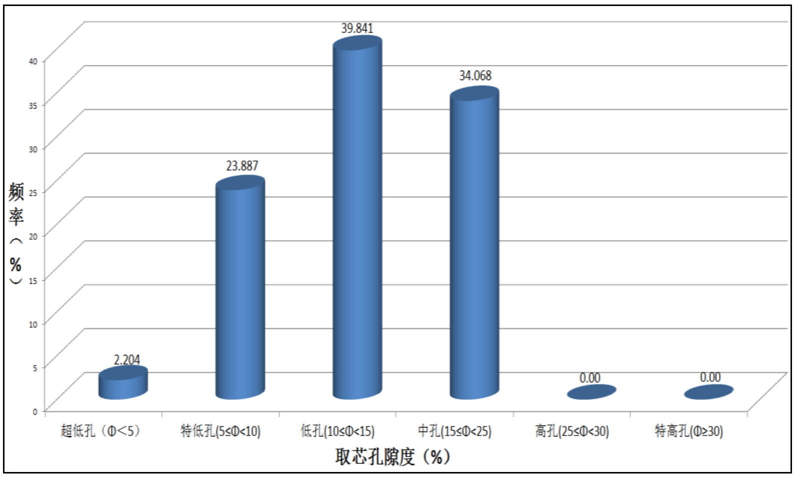
$$\phi = \frac{(AC - AC_{ma})}{(AC_f - AC_{ma}) * CMP} - C_1 * V_{sh} * \frac{(AC_{sh} - AC_{ma})}{(AC_f - AC_{ma})} + k_1 + k_2 \quad (5)$$

In which: k_2 is the porosity correction based on micro facies type, the value sees tab.2.

Finally, using formula (5) explains all 310 wells in area, obtaining the high correlation between the porosity by interpretation and the porosity by core measurement, and the correlation coefficient R is as high as 0.831 (Figure 3a). Statistics of the absolute error was 0.463%, it's a high precision. In addition, the interpretation results and the measured results of core porosity have a high coincidence rate. The percentage of each interval is very close, and the results show that the super low porosity 2.204%, special low porosity 23.887%, low porosity 39.841%, medium porosity 34.068%. Corresponding, in the results of interpretation,the super low porosity 0.06%, special low porosity 16.31%, low porosity 56.49%, medium porosity 27.13% (Figure C, 3b).This can prove the accuracy and the rationality of the porosity model in the target area.



a



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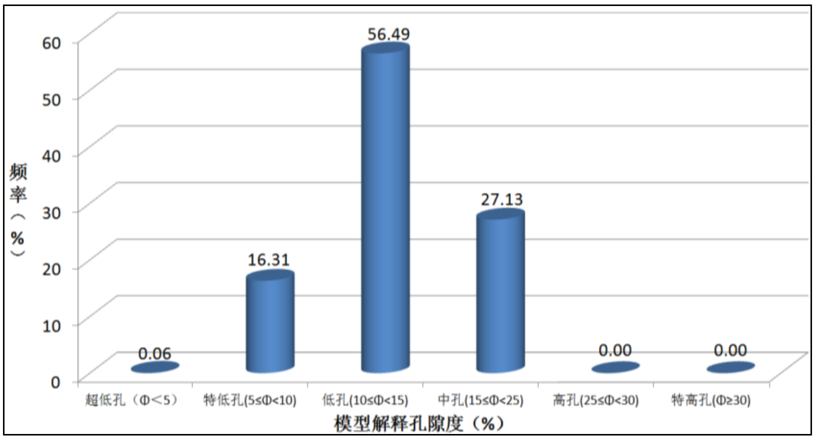


c

Fig.3 Comparison of porosity interpretation results in model and core data

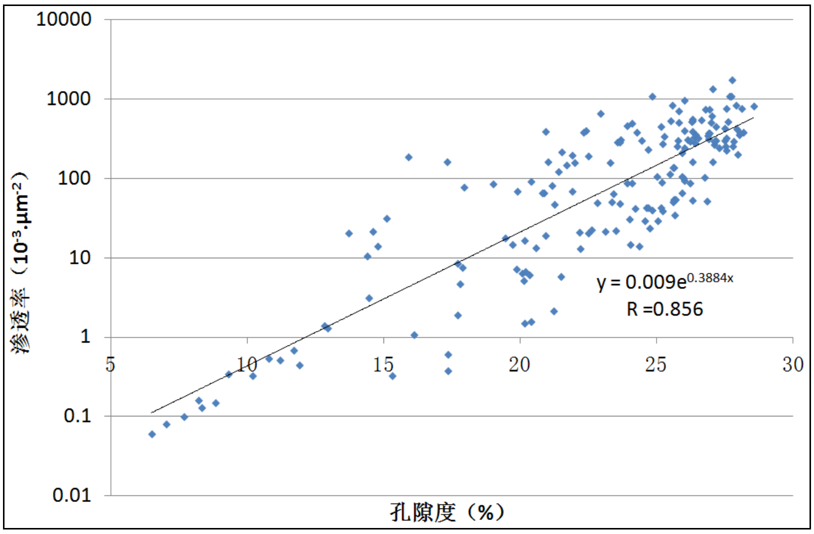
3. 3 Permeability interpretation model

Reservoir permeability is one of the another important basic parameters in reservoir physical property evaluation, Meanwhile, it's one of the important factors that affect the development of the oil reservior. Currently there are many ways to interpret the permeability, but most have some defects or lack of adequate theoretical basis to support. In many ways, more practical method should be regression fitting based on petrophysical relationship, the main research in this paper is based on this method.

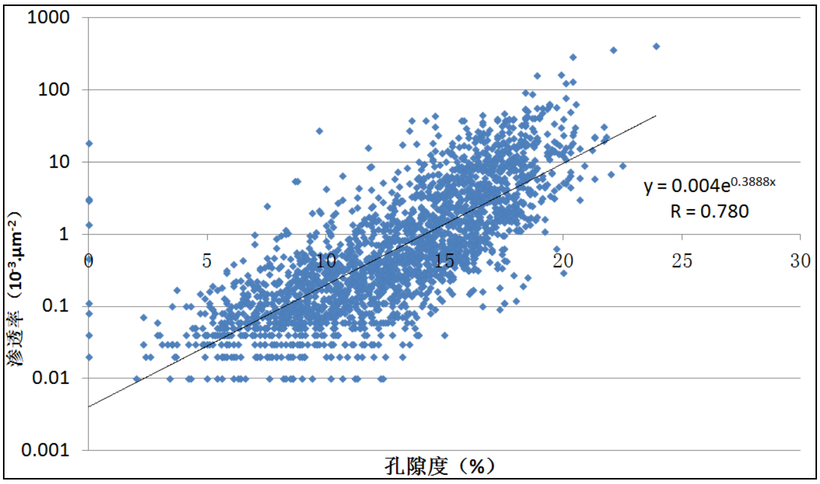
Reservoir permeability not only affected by the pore structure, the content of mud, porosity, etc. It is also influenced by sedimentation, diagenesis and structure. In this paper, we mainly consider the factors of sedimentation.A method for interpretation of the permeability which is classified by the types of sedimentary facies is proposed. There are two categories according to the type of sedimentary microfacies of the core. One is the dominant facies which contains the channel sand. The other is the microfacies, which is composed of the sheet sand in inner and outer front. In this paper, the sample point of channel sand has 176 points data. And the sample point of sheet sand contains 2095 points data. Thus, permeability interpretation model are established respectively. Fig.4a and Fig.4b represent the fitting formula of the river channel and the sand sheet sand.

Taking channel sand as the representative: $k = 0.009 * e^{0.3884 * \phi}$ the correlation coefficient R=0.856 (6)

Taking sheet sand as the representative: $k = 0.004 * e^{0.3888 * \phi}$ the correlation coefficient R=0.780 (7)



A Fitting of the permeability formula with the channel sand



B Fitting of the permeability formula with the sheet sand

Fig.4 The establishment of the model of permeability interpretation

IV. CONCLUSION

ording to the type of sedimentary microfacies of the core. One is the dominant facies which contains the channel sand. The other is the microfacies, which is composed of the sheet sand in inner and outer front. In this paper, the sample point of

1) Through the method of curve standardization, principal component analysis and core location, to the greatest extent reduces the error which caused by the initial data.

2) The porosity interpretation model, which is composed of the correction factor, the compaction correction factor and the correction factor based on the types of sedimentary facies is established. And the absolute error is 0.463% and the correlation coefficient is 0.831.

3) The permeability model was established by the types of the sedimentary facies and the correlation coefficients were 0.856 and 0.780, respectively.

4) The average porosity of the target area log interpretation is 13.29%, the distribution range was 2.245-21.670% which take special low, low, medium porosity as main, respectively accounted for 16.31%, 56.49%, 27.13%. The average permeability is $1.453\times10^{-3}\ \mu m^2$, the distribution range was $0.022\text{-}20.479\times10^{-3}\ \mu m^2$ which take ultra low permeability, extra-low permeability as main, respectively

accounted for 55.25%, 40.08%. The W reservoir in H oilfield is a low porosity and ultra-low permeability reservoir.

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