Fine study on well logging data and reservoir characteristics

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Abstract. In this paper, the sand group 9 of the second member of Shahejie Formation in the second area of Shengtuo oilfield is taken as the research area. Combined with the geological and development dynamic conditions, the core well analysis and test data, oil test data and production test data are used to fully mine the identification ability of logging data for oil and gas reservoirs, establish the interpretation model of porosity, permeability and saturation in the research area, determine the lower limit standard of effective thickness, and improve the accuracy of reservoir interpretation. The accuracy lays a foundation for the remaining oil to tap the potential.

Key words: Log secondary interpretation, Shengtuo Oilfield

With the deepening of oilfield development, the precision of reservoir research is constantly improving, and the rich geological data and the improvement of logging technology also provide the basis for the accurate secondary interpretation of old oilfield logging data.

Shengtuo oilfield is a multi-layer medium and high permeability integrated reservoir, which has entered the late stage of ultra-high water cut development [1]. Sand group 9 in the second member of Shahejie Formation in the study area is a delta front deposit, which is interpreted as a medium and high permeability reservoir by well logging, but the water injection effect is poor in the actual development and production. The latest core material shows that the reservoir permeability is between 50-100 × 10-3 μm2, which is a medium and low permeability reservoir [2]. Therefore, it is necessary to standardize and reinterpret the existing logging data to meet the needs of geological research and development.

1. Well logging data standardization

Reservoir physical properties and porosity are important indicators to characterize reservoir capacity, permeability is the main parameter to indicate reservoir permeability, reservoir lithology is an important weight to determine the difference of electrical characteristics of oil, gas and water layers, and oil-bearing parameters are important indicators for quantitative interpretation and evaluation of logging oil-water layers [3]. Therefore, accurate calculation of reservoir parameters is the basis for establishing logging interpretation model. It is also the key to log interpretation. In order to improve and ensure the accuracy of reservoir parameter calculation, it is necessary to standardize well logging data. Working principle design of oilfield research system refer to figure 1.
The methods of well logging curve standardization mainly include standard layer comparison method, core analysis method, histogram method, frequency cross plot method, trend surface analysis method and so on. Different methods have different application ranges. There are good standard layers in the study area, and the standard layer correlation method is used in the standardization of logging curve.

1.1 Selection of standard layer
The standard layer is the basis of all standardization work, and its selection shall meet the following conditions: ① stable deposition with a certain thickness (generally greater than 5m); ② obvious lithologic and electrical characteristics, convenient for tracking and comparison in the whole area; ③ wide distribution, more than 90% of wells in the work area are drilled; ④ a single layer or a layer group, close to the interpretation horizon. After comparison, a set of 15-25m thick mudstone at the bottom of 8 sand formation of Sha2 member is selected as the standard layer in the study area.

2. Well logging curve standardization
The method of frequency histogram is used to standardize the acoustic time difference curves of 416 wells in the study area [4]. On the basis of fully considering the instrument system error and reading value error, the standard histogram of acoustic time difference is depicted (Figure 1). The standard value of acoustic time difference is determined to be 360-370 μs / m, and the parameter value and standard value of each well standard layer are compared one by one, and the acoustic time difference is standardized respectively. At the same time, in order to ensure the stability of the acoustic wave in the local range, the adjacent well comparison method is used for auxiliary correction. Establishment of logging interpretation model. Working principle of reservoir characteristics research system refer to figure 2.
Figure 2. Working principle of reservoir characteristics research system

In the actual development and production, there are generally 1-2 coring wells in a certain area, so it is impossible to establish an interpretation model [5]. Therefore, under the guidance of geological knowledge, the logging interpretation model is established by borrowing the coring well data in the adjacent area under the same regional tectonic background.

2.1 Porosity interpretation model

In the conventional logging curves, the curves that reflect the sensitivity of porosity mainly include density, neutron and acoustic time difference. When establishing the porosity interpretation model, considering that most wells only have acoustic time difference curve, the multiple regression method is used to establish the interpretation model.

Read the average value of the logging curve for the reservoir in the core section of the study area, if the vertical heterogeneity is serious, then read in sections [4]. The cross plot of acoustic time difference and core analysis porosity is made by using electrical analysis results to establish the relationship between porosity and acoustic time difference. Where, $\varphi$ is porosity,%; $\Delta t$ is acoustic time difference, $\mu s / M$; $R$ is correlation coefficient.

2.2 Permeability interpretation model

The relationship between logging response and permeability is very complex due to the influence of many factors such as the size of rock particles, pore throat radius, fluid properties and clay distribution [6]. Log interpretation uses the physical property analysis data of 22 core samples in the study area to draw the cross plot of core analysis porosity and permeability, and establishes the permeability interpretation model of sandstone section:

Where: $K$ is permeability, MD; $\varphi$ is porosity,%; $R$ is correlation coefficient.
2.3 Saturation interpretation model
The basic method to determine the saturation is usually based on resistivity logging, which connects the physical property, oil-bearing property and electrical property of the reservoir through Archie formula. Therefore, the saturation interpretation model needs the saturation data of sealed core wells or oil-based mud core wells. The empirical formula of data regression of 26 layers of oil-based mud wells in the study area is used to calculate the water saturation. The specific formula is as follows:

\[ S = \frac{h \times \rho}{\phi \times RT} \]

3 in which h sounding, m; \( \phi \) is porosity, \%;

\( RW \) is formation water resistivity, \( \Omega \cdot \) m; \( RT \) is formation resistivity, \( \Omega \cdot \) M.

3. Determination of the lower limit standard of effective thickness
Based on the comprehensive utilization of core analysis data, oil testing and production test data, production data and logging data at the initial stage of development well, the corresponding lower limit chart is made, and analyzed and compared to determine the effective thickness standard of the second member of Shahejie Formation in the study area.

3.1. Lower limit of lithology and oil content
According to the core observation, single-layer oil test and production test data, the lower limit of lithology and oil-bearing property in the study area is determined as oil-immersed siltstone.

3.2 Electrical lower limit
The effective thickness electrical property standard is established by selecting single test bed with good logging quality and well hole conditions. Select 6 wells and 8 single test layers, and establish the intersection chart of acoustic time difference and induced resistivity. According to the chart, the lower limit of thickness acoustic time difference of sandstone section is 280? S / m, and the lower limit of induced conductivity of oil layer is 2.85ms/s.shown as the flow figure.

3.3 Mezzanine deduction standard
There are two types of interbeds in the study area: argillaceous interbed and gray interbed, among which gray interbed is relatively developed. The gray intercalation mainly shows that the microelectrode curve is in peak shape, and there is no amplitude difference or the amplitude difference is very small, the acoustic time difference is small, and the resistivity is high; the muddy intercalation mainly shows that the natural potential returns, and the resistivity becomes low.

3.4 Application of logging interpretation results
Based on the above-mentioned well logging interpretation model and the lower limit standard of effective thickness, 416 wells in the study area were interpreted twice, including 410 oil layers, 67 water layers and 265 dry layers. According to the test of the established interpretation model, the log interpretation result map in the study area shows that the porosity and permeability of log interpretation are highly consistent with the porosity and permeability of core analysis, and the effect of the established interpretation model is good.

4. Log interpretation results of a well in the study area
Through the secondary interpretation of fine logging of sand group 9 in the second member of Shahejie Formation in the second area of Shengtuo oilfield, the average effective thickness of the main area is increased by 0.9m, and the geological reserves are increased by 330000t; the effective oil-bearing area of the original sand body is expanded by 2.21km2, and the reserves of low-permeability reserves are increased by 420000t.
5. Conclusion

With the development of oil field in the late stage, the requirement of fine reservoir research is constantly increasing. It is necessary to study the old oil field reservoir with the method of log secondary interpretation based on the standardization of logging data, establish the interpretation model of porosity, permeability and saturation, determine the lower limit of effective thickness, improve the accuracy of oil and gas reservoir interpretation, and re understand the reserves scale and nature To provide the basis for the old oilfield to reasonably formulate the development adjustment plan.

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