Based on Computer Aided Technology, the Analysis of Percolation and Oil Recovery in Peripheral Tight Reservoir and its Test Results

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Abstract. Due to the relatively long time interval between the completion of mining and the flooding of bottom water, the identification of oil-water layer is difficult due to the same nature of formation crude oil, so the interpretation of oil layer is very challenging. In this paper, the boundary oil, injection oil and bottom oil propellants of each oil layer in the study area, as well as the oil source and inflow direction of the oil layer, are summarized by using computer aided technology according to the geological characteristics of the block and the characteristics of permeability and oil recovery. The resistivity of water injection, oil flooding at the side and the bottom decreased obviously. Secondly, the typical reservoir of the new well is determined by comparing the logging data of the same layer between the old well and the new well and combining with the production dynamic test results of the adjacent old well. The logging response characteristics of the reservoir are analyzed, and the sensitive parameters such as deep lateral resistivity, shallow lateral resistivity, deep lateral resistivity amplitude difference, deep lateral resistivity, flush resistivity amplitude difference are optimized.

Keywords: Oil-flooded Layer, Injected Oil, Edge Oil and Bottom Oil, Qualitative Logging Interpretation, Dynamic Production Analysis, Computer Aided Technology

1. Introduction
In the process of oil recovery, there are some phenomena, such as edge oil advancing, bottom oil coning and injected oil flooding. The oil content of the oil field continues to rise. At present, the oil content is 76.4%, which has entered the middle and high oil-bearing period [1-2]. The difficulty of oil flooding interpretation is increased, and the oil plugging effect is not significant. It is the primary task to find the remaining oil and evaluate the oil-flooded level of the reservoir at present. Because there is no new closed coring data for determining the oil-flooded level of the reservoir in this block, most of the wells are mainly produced in combination, with very few single-layer production and test data [3-4], and the interval between production and completion is long, which makes it difficult to determine the single-layer oil-flooded dynamic, because the properties of the stratum crude oil are the same, It is difficult to identify the bottom oil-flooded layer and the same layer of oil and oil. Therefore [5-6], in view of the evaluation problem of oil-flooded layer in block P, this paper proposes a comprehensive
evaluation method of oil-flooded layer logging based on the technology of permeability and oil recovery of peripheral tight reservoir. The logging information can accurately reflect the oil-flooded condition of each oil layer at a certain time, However, the technical data of imbibition and oil recovery in the outer tight reservoir can reflect the oil-flooded status of the oil reservoir at each time, and the static well logging interpretation results and dynamic production data have advantages in the evaluation of oil-flooded layer, It can improve the accuracy of oil-flooded layer interpretation. Great progress has been made in basic experiments, optimization of logging series, interpretation models and interpretation methods of oil-flooded layer logging in China

2. Determination of typical oil-flooded layer based on dynamic and static combination
According to the geological features and oil recovery features of the block, oil source and oil inflow direction of the oil-flooded layer, two types of oil-flooded are summarized: edge oil and injection oil advancing oil-flooded type and bottom oil advancing oil-flooded type. Edge oil refers to the oil beyond the outer boundary of the oil, while edge oil is actually the natural extension of the bottom oil, injection oil refers to the oil injected into the reservoir. Edge oil and injection oil migrate along the reservoir, as shown in well B in Figure 1, In perforation production of well B, the edge oil migrates to well B along reservoir II. Well B is the oil seen. Reservoir II near well B is the edge oil-flooded type. The bottom oil refers to the oil within the outer boundary of oil, which is in contact with the oil, and under the oil and gas to support the oil and gas. The bottom oil is vertical migration. When the oil breaks through the bottom of the well, the oil well is the oil production. As shown in Figure 1, the oil body of reservoir I is located in the lower part of the oil layer, and well C is perforated for production, and the oil breaks through the bottom of the well, Well C produces oil from bottom oil and reservoir I near well C is bottom oil-flooded type
Because the oil flooding in the study area is caused by the edge and bottom oil of the reservoir and the oil (dirty oil) produced by the oil well, and the change of the original oil salinity is small, the salinity of the mixed oil in the study area is similar to that of the original oil, Through comparative analysis of geological data, oil testing data, production dynamic data, liquid production profile data of adjacent new and old wells in the study area, combined with the logging curve features of the same layer of new and old wells, the typical oil-flooded layer is determined.

![Figure 1. Schematic diagram of oil-flooded type](image)

3. Quantitative assessment of oil-flooded layer
Through the analysis and study of logging response features of sandstone and mudstone in the block, it is found that the neutron density logging combination can well reflect the lithologic change of sandstone and mudstone in the block, thus establishing the calculation formula of shale content in the block. Through the comparative study of core analysis of porosity and three porosity logging responses in the block, it is found that the density logging can well reflect the change of reservoir porosity in the block, Thus, the calculation formula of reservoir porosity in the study block is established

$$\phi = \frac{\rho_{na} - \rho_h}{\rho_{na} - \rho_{nf}} - V_{sh} \frac{\rho_{na} - \rho_{sh}}{\rho_{na} - \rho_{nf}}$$  \hspace{1cm} (1)
Where $\phi$ represents porosity, decimal

The average absolute error between the porosity of 55 layers of 9 wells in the study area calculated by the above formula and that of core analysis is 1.1%, indicating that the porosity of the reservoir in the study area can be determined by the established porosity calculation formula.

Using the core analysis porosity and permeability data of YI-IV sand formation, YV-VIII sand formation and S sand formation, the calculation formulas of reservoir permeability are established respectively, as shown in Fig. 7.

$$
K = \begin{cases} 
8.639471 \times 10^{-4} e^{0.456\phi} & \text{YI-IV} \\
1.108278 \times 10^{-4} e^{0.669\phi} & \text{YV-VIII}(\phi \leq 24\%) \\
4.725694 e^{0.222\phi} & \text{YV-VIII}(\phi > 24\%) \\
0.01 e^{0.4917\phi} & S 
\end{cases}
$$

The average relative error between the permeability of 55 layers of 9 wells in the study area calculated by the above formula and the permeability of core analysis is 65.1%, which shows that the calculated permeability and the permeability of core analysis are in good contrast, and the reservoir permeability of the study area can be calculated by the above formula.

4. Comprehensive assessment of oil-flooded layer based on dynamic static combination

The qualitative recognition method of oil-flooded layer established in this paper not only uses the amplitude value information of resistivity curve, but also uses the amplitude difference information of resistivity curve to comprehensively identify oil-flooded layer, oil layer and oil layer, but cannot divide oil-flooded level, and the recognition effect of oil-flooded layer is affected by the change of lithology and physical properties. For example, the reservoir with high shale content is similar to the oil-flooded layer with high oil-flooded degree in electrical features, which shows that the amplitude value and amplitude difference of resistivity are reduced, which is difficult to distinguish, while the quantitative assessment method of oil-flooded layer not only uses the amplitude value information of resistivity curve, but also uses the amplitude value information of logging curve reflecting the change of lithology and physical properties. The oil saturation and irreducible oil saturation of reservoir are calculated synthetically, and then the oil displacement efficiency can be used to divide different oil-flooded grades, but the discrimination effect of oil-flooded grades is affected by the accuracy of parameter calculation. The qualitative and quantitative interpretation method of oil-flooded reservoir only uses the static logging information, and does not consider the dynamic production information of the region. In summary, In this paper, the idea of dynamic and static combination of oil-flooded layer comprehensive interpretation is put forward. For the recognition of oil-flooded layer of edge oil and injected oil-flooded type, first use the qualitative recognition chart of oil-flooded layer to distinguish the oil-flooded layer from the oil reservoir, then use the quantitative assessment method of oil-flooded layer to determine the oil-flooded level, and finally combine the production dynamic data of adjacent wells. For the recognition of the bottom oil-flooded layer, the first step is to determine the depth of the top interface of the same oil layer through the well connection profile at the initial stage of imbibition oil recovery, and then to distinguish the same oil layer and bottom oil-flooded layer by combining the imbibition oil recovery technology of the surrounding tight reservoir. This method combines the advantages of static logging interpretation and dynamic production analysis in the assessment of oil-flooded layer, It makes up the technical defect of single interpretation method in oil-flooded layer assessment, and can further improve the coincidence rate of oil-flooded classification interpretation.

Based on the determined oil-flooded layer, the well logging information of oil layer and obvious oil layer determined according to the oil testing data and production data, the well logging response features of oil-flooded layer are analyzed, and the oil-flooded sensitive parameters used for oil-flooded layer recognition are optimized. The characteristic contrast
map of the main change range of the well logging response of oil-flooded layer, oil layer, deep lateral, shallow lateral and flushing electric resistivity of the five fault blocks in the study area, It can be seen from the figure that the deep lateral and shallow lateral resistivity values of the oil-flooded layer in the study area are significantly lower than the deep lateral and shallow lateral resistivity values of the oil layer, and higher than the deep lateral and shallow lateral resistivity values of the oil layer, and the main variation range of the deep lateral and shallow lateral resistivity values of the oil-flooded layer and the oil layer is obviously separated, However, the main range of flushing resistivity of oil-flooded layer coincides with that of oil layer and oil layer

![Figure 2. Relationship between permeability and porosity](image)

The comparison chart of the features of the main variation range of the amplitude difference between the oil-flooded layer and the oil layer, the deep side and the shallow side of the oil layer, and the deep side and the flushing electric resistivity of the five fault blocks in the study area can be seen from the chart, In the study area, the amplitude difference of deep lateral and shallow lateral and deep lateral and flushing electric resistivity of oil-flooded layer is generally lower than that of deep lateral and shallow lateral and deep lateral and flushing electric resistivity, higher than that of deep lateral and shallow lateral and deep lateral and flushing electric resistivity, In addition, the main range of variation of the amplitude difference of electric resistivity between the oil-flooded layer and the oil layer, between the deep side and the shallow side of the oil layer, and between the deep side and the flushing is relatively large

5. Conclusions
The types of oil flooding in the study area include edge, injection, advancing oil flooding, and bottom advancing oil flooding, mainly edge oil and injection advancing oil flooding. Among them, the bottom oil advancing oil-flooded layer mainly occurs in the YIV, YV, YVI, and YVII sand formations. The resistivity logging response features of oil injected and edge bottom oil flooding presented a significant decline in resistivity. The sensitivity parameters of logging oil flooding are deep lateral resistivity, shallow lateral resistivity, deep shallow lateral resistivity amplitude difference, deep lateral resistivity, and flushing electric resistivity amplitude difference can be determined through the comparison of the logging information in the same layer of new and old wells, combined with the production dynamic test and analysis of adjacent old wells. Among them, the amplitude difference of deep lateral resistivity and deep shallow lateral resistivity are the most effective parameters for the recognition of the oil-flooded layer. The qualitative recognition diagram of the oil-flooded layer established by the intersection of deep lateral resistivity and deep shallow lateral amplitude difference can distinguish the oil-flooded layer, oil layer, and oil layer properly. The parameters such as shale content, porosity, permeability and saturation calculated based on the established quantitative interpretation model for the oil-flooded layer comply with the core analysis results. This suggests that the accuracy of the parameters calculated is high, which is suitable for interpreting the oil-flooded layer in the study area. The displacement efficiency calculated and the classification standard for the oil-flooded level, the weak, medium, and strong oil-flooded layers can be classified effectively. The comprehensive qualitative recognition plate and quantitative interpretation methods for the oil-flooded
layer, combined with the production dynamic of adjacent wells, can interpret the oil-flooded layer. The comprehensive logging assessment method can leverage the advantages of static logging interpretation and dynamic production analysis in assessing the oil-flooded layer and improve the accuracy in the comprehensive logging assessment of the oil-flooded level.

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