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Oil and Water Layer identification by Dual-frequency Resistivity Logging

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Abstract: Rock electrical parameters (resistivity, dielectric constant) dispersion is one of important characteristics of rock,the logging with the rock resistivity dispersion characteristics developed - dual frequency resistivity logging method, is expected to improve and enhance the continental sedimentary strata oil-gas evaluation quality and ability. Dispersion characteristics of application of electrical parameter frequency for formation evaluation is the main feature of dual frequency resistivity logging. Dual frequency resistivity logging which has good adaptability for different lithology, porosity, different, different layers, different salinity can be inclusive, the coincidence of the interpretation of dual frequency resistivity logging for oil-water layer is very high, and it has the characteristics of simple, intuitive, high precision, high efficiency, low cost. This paper introduces the basic principle and the theoretical basis of double-frequency resistivity logging and the utilization coefficient of correction on the basis of the basic concept of logging,distinguish oil and water layer. With some wells through to Sue Jin Noel field experiments, trying to draw specific method to get the coefficient, the oil and water layer evaluation has achieved good results, proving the double-frequency resistivity logging method has good intuitiveness and accuracy for reservoir evaluation,so this well logging technology has a good application prospect.

Keywords: *dual-frequency resistivity logging； dispersion phenomenon coefficient of orrection； geological application； the effect of the evaluation*

I. INTRODUCTION

Double-frequency resistivity log is the creation and development of a new logging workers resistivity logging method, this method first, Xinjiang well logging company Mr Deng put forward and implemented, through our research, test and improvement,we have eight in China for six years and more than 150 large sized oil field logging, and obtaine good geological effect. These Wells in the oil and water layer from upper Paleozoic to Cenozoic strata, from siltstone and conglomerate, from close to the skeleton of low porosity to diagenetic difference of high porosity, from 1000 PPM of high formation water salinity to 300000 PPM of high formation water salinity, from clastic rock intergranular pore to igneous rock seam hole type pore and so on have been a good application.

Evaluation of oil and water layer is the first task of petroleum geophysical well logging and resistivity logging in oil and gas zone evaluation has always been the core of the field of geophysical well logging technology. In many aspects, such as evaluation and calculation of reserves of oil and gas is less than by other methods, especially for large sedimentary thickness, good uniform lithology, physical property and formation water salinity is stable under the condition of Marine sedimentary formation, resistivity logging are uniquely for decades. In mainly continental deposit oil field of our country, although the importance of resistivity log is still in the first place, but have met insurmountable obstacle, that is: low crude complex and changeful lithology and formation water salinity and varied problems[1]. The authority has been challenged and questioned. Correction of these problems have not been effectively, often make people are in a embarrassing helpless situation log analysis, we find new logging method to solve these problems, double-frequency resistivity log so arises at the historic moment.

II. LOGGING PRINCIPLE

First, we introduce the concept of strata "dispersion phenomenon" . The measured formation resistivity which is referred to under different current frequency is different. Reservoir has the characteristics, so we say that reservoir have dispersion phenomenon. Layer under different current frequency of the same or similar formation resistivity water layer reported no dispersion phenomenon. Reservoir dispersion phenomenon with the oil saturation of reservoir and current frequency varies, the reservoir of the dispersion phenomenon is the result of the reservoir has a capacitive, oil saturation is higher, the stronger the capacitance, the lower the capacitive reactance, so the total resistivity is lower than the low resistivity values. Current frequency, the higher the

dispersion phenomenon, the greater the total resistivity drops are more serious. In some of the current frequency dispersion phenomenon only related to the formation of oil saturation. Therefore provides a formation dispersion phenomenon is used to distinguish between oil and water layer, then the possibility of formation oil saturation ratio, and formed the dual-band resistivity log.

Unlike previous resistivity log, resistivity log is made before gradually transform to the electrode size or by focusing effect, to eliminate or overcome the effects of borehole effects and mud invasion. Double-frequency resistivity log using a new perspective that is using the same electrode system and different current frequency to measure the formation resistivity. The same electrode system (size) is to make the borehole effect and mud invasion influence, the ratio of benefit through them to eliminate their influence; One for the low frequency to high frequency current of different frequency differences reflect the oil-water layer dispersion phenomenon, help to distinguish between oil and water layer, and that under certain current frequency dispersion effect caused by resistivity difference and ratio is only related to the formation oil saturation.

We can imagine, between two sand can form a capacitor, the following figure 2-1:

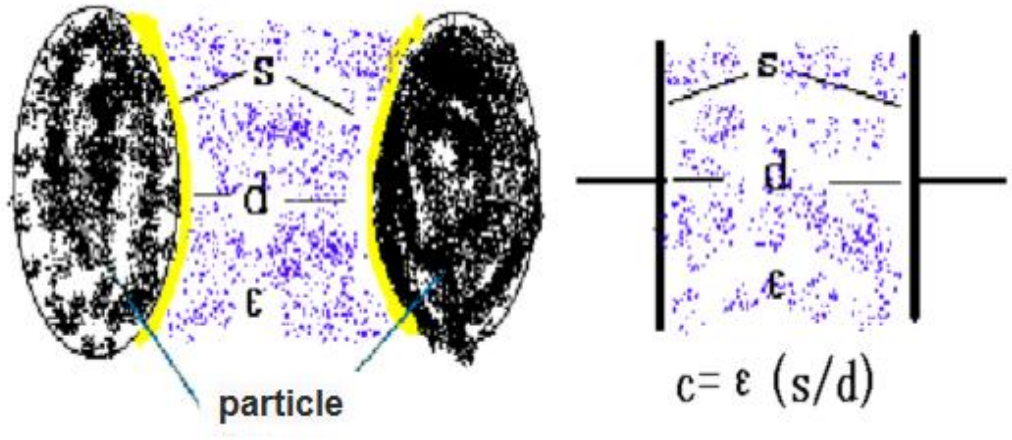

Figure 2-1 the capacitor which is formed between the sand

Dual-frequency resistivity log resistivity curve, respectively for low resistivity RD and high frequency resistivity Rz, the measurement of the physical model can approximate to the following figure 2-2:

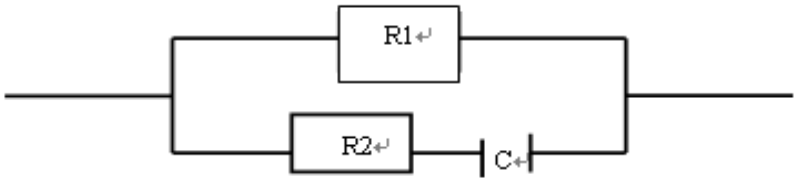

Figure 2-2 approximate physical model.

Low resistivity measurements of R1 resistor shunt, high-frequency resistivity measurement of two parallel value of shunt. Under normal circumstances, the water layer at low frequency, high frequency resistivity value is close to, when the reservoir resistivity low resistivity is high value, high frequency value is relatively low or their ratio greater than 1. If the current value of the tight sandstone in two frequency overlap, the water layer when low frequency current higher than that of high frequency current, high frequency current when the reservoir is higher than the low frequency current[2]. Which can indicate the formation of oil content and qualitative distinction between oil and water layer and water flooded layer.

Due to reservoir dispersion phenomenon, the measured Rz value has not accord with the requirement of archie formula (note: archie formula is only suitable for low frequency measurement current conditions), is currently with R_1 (R_D) and the ratio of Rz and pressure coring analysis data to establish a relationship to solve formation oil saturation, and obtained very high precision relationship equation.

Formation water, formation of electrical interface is less and the distance between interface is larger, so the water layer with less electricity capacity and higher capacitive reactance. Oil bearing strata, the formation of the electrical interface increase, reduce the distance between interface, so the reservoir with high and low capacitance of capacitive reactance.

Oil bearing strata, high frequency resistance rate is lower than that of low resistivity, reduce numerical values and formation oil saturation and current frequency on. When in mudstone (think of mudstone water saturation is 100%) make low resistivity and high frequency equals the resistivity overlap, the ratio of them in aquifer close to 1, when the reservoir is greater than 1, the ratio of oil and water and water flooded layer tree between among them, the size of the viewing ratio to explain the stand or fall of oil-water namely oil or water flooded degree of weak[3]. The water flooded layer interpretation of the quantitative standard. This is the interpretation of water flooded layer resistivity method a progress.

III. THE APPLICATION OF DUAL-FREQUENCY RESISTIVITY LOGGING

Through the experiment, we use ratio method will be shallow lateral resistivity logging and deep induction logging resistivity measured by comparison. We defined the ratio is about 1 layer, slightly greater than 1 for poor reservoirs, the ratio of 1.5 or so can be explained by the oil and water, tree ratio close to 2 explanation for the reservoir, but need to shallow lateral resistivity value after processing, oil and water layer is obvious characteristics.

We in hailaer basin Suzy Noel oilfield several Wells as an example to carry on the processing. An overview of first introduce Suzy Noel oilfield.

Under the simple understanding after the district profile, we come to the specific of the coefficient method are obtained.

After many attempts to find such resistivity logging methods are greatly influenced by the density, thus it is concluded that through the following methods will be shallow lateral resistivity value for processing after the numerical comparison with induction resistivity value for oil and water zone evaluation more accurate.

First, calculating the average of the density (DEN), and then do with maximum and average density difference, it is concluded that the numerical a, then use 1 and a poor do get coefficient b. Use the coefficient b and shallow lateral resistivity value multiplication, plus a * mudstone resistivity. Formula is as follows:

$$Z = [1-(Den_{\max} - \overline{Den})] * RLLS + R * (Den_{\max} - \overline{Den}) \qquad (3\text{-}1)$$

R----------Mudstone resistivity，Ω

Z----------After processing the shallow lateral resistivity value，Ω

Using the method of shallow lateral resistivity values and then compared with induction log resistivity values. When the ratio is less than or equal to A 1, interpreted as water layer. When the ratio of A slightly greater than 1, can be interpreted as poor reservoirs. When the ratio of A is greater than 1 is large, interpreted as reservoir.

Applying this formula for oil and water layer identification and compared with the manual interpretation results, explained the results coincidence rate is higher.

IV. DOUBLE-FREQUENCY RESISTIVITY LOGGING TECHNOLOGY APPLICATION CHARACTERISTICS

1) We can identify the oil and gas layer accurately in the development of the new city under the condition of no water for reference.
2) In complex glutenite, igneous rock formation,we can evaluate oiliness and variation of reservoir in the effective elimination of the lithology reliably .
3) We can identify oil and gas layer in formation water mineralization degree and changeable situation.
4) Used for evaluation of low resistivity reservoirs.
5) For a lot of people especially water injection reservoir of fresh water can effectively evaluate the water flooded layer and water flooded degree.
6) Three times for oilfield development the need of production, can effectively evaluate a large number of polymers containing oily and variation of reservoir.

Dual-frequency resistivity log basically eliminate and overcome the lithology and salinity change on the influence of resistivity, the interpretation coincidence rate of oil and water layer is high, has reflected the dual-band resistivity log interpretation coincidence rate of the problem[4]. You can see from this, double-frequency resistivity logging has a good adaptability, different lithology and different porosity, different layers, different salinity tolerance, may be called the resistivity logging a breakthrough.

V. CONCLUSION

Double-frequency resistivity logging method in a large extent, overcome the changes of lithology, mineralization and their causes, the influence of can intuitively show that formation oil content, its solving undisturbed formation and water flooded layer interpretation of the oil saturation with high accuracy, for the analysis and calculation of the residual oil remaining reserves provides an important parameter, fill in the

conventional resistivity logging in freshwater can't quantitative interpretation of water-out reservoirs of water saturation. Double-frequency resistivity logging has a good adaptability, different lithology and different porosity, different layer and different salinity may be inclusive, double-frequency resistivity logging interpretation coincidence rate of oil and water layer is very high, and it has intuitive, simple and the characteristics of high precision, high efficiency, low cost, with the constant improvement of double-frequency resistivity logging, enrich and develop, it will get more extensive application.

Dual-frequency resistivity logging has intuitive reflect to the oil reservoir conditions, contain oily response is the first, lithology and salinity and other factors on the impact position. In order to overcome or reduce the influence of lithology and salinity on resistivity provides a new logging method. Is expected that the low resistivity oil and gas layer, water flooded reservoir, igneous rock and breccia special lithologic hydrocarbon reservoirs of the difficulty in the evaluation of oil and gas, by dual-frequency resistivity log will get different degrees of solution, because they are in essence is caused by salinity and lithologic factors. Different water level and water flooded reservoir level on the dual-frequency resistivity logging data with different scale and easy to distinguish, it is the differences in quantity can meet the needs of the well logging interpretation. Therefore, double-frequency logging resistivity of water flooded layer provides a new effective method. » double-frequency resistivity interpretation of reservoir oiliness oneself information without water for reference only, and the method in the detection of the depth of the strata in today's all logging method is one of the more deep, so reflect stratigraphic primitive state, most powerful is a supplement to the existing resistivity logging methods, development and improvement. Dual-frequency in dealing with formation resistivity logging evaluation of oil and gas as well as the geological problems, such as low level of water flooded reservoir application effect is good, shows good application prospect of dual-band resistivity logging.

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