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Fracture Identification by Logging Datas

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Abstract: Fracture is the main factor to determine oil and gas production capacity in low permeability reservoir. Only by acquiring the information of the fracture development in the formation can the reservoir be evaluated accurately. With the development of science and technology, more and more logging technology can be used in the identification of cracks, Such as: sonic logging, density logging, imaging logging, the full wave logging, dip logging, and PP wave logging technology which can identify fractures near borehole. In this paper, several methods of identifying fracture by logging curves are briefly introduced.
Keywords: Fracture, gas production, reservoir, identification of cracks.

INTRODUCTION

Fractured reservoir has many special characteristics. In terms of its physical and rock properties and the depth of the mud, there are obvious differences and heterogeneities in the profile, there are different cracks and caves, which has many different fractures and caves [1]. So the rock sound, electricity, discharge and other features have a large range of changes and uncertainty. The fracture developing probability can be predicted through the methods of the reconstruction of conventional logging curve, amplifying the fracture response characteristic in conventional logging curves and extracting the fracture imaging logging information features.

LOG INTERPRETATION MODEL OF DUAL POROSITY STRUCTURE

Porosity is not a single concept in complex reservoirs. So 4 porosity concepts are introduced, which are total porosity, matrix porosity, porosity and fracture porosity. The following models are established according to the reservoir types. The aim is to put the total porosity into 2 parts, matrix pore and fracture pore, which is the model of double pore structure [2].

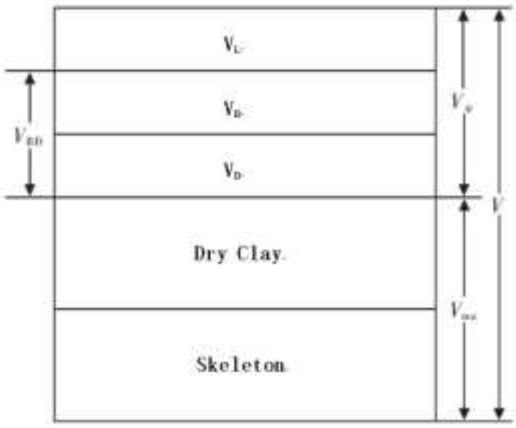

Fig-1: Geological model of double pore structure

Pores and caves are usually distributed in the rock, when there is no fracture in the communication, the holes are communicated by the matrix [3]. Their existence has a great influence on the total porosity, the total porosity increases exponentially when the holes are relatively developed. But the effect of cave size on the conductivity of rock is very little. In the establishment of the interpretation model, cave and Matrix pore are regarded as one called matrix cave pore. The existence of fracture pore has little effect on the total pore, but it has great influence on the conductivity of the rock. So the dual porosity model is composed of 2 parts [4], the fracture pore and the matrix cave pore (formula 1).

$$\varphi_T = \frac{V_\varphi}{V} = \frac{V_{BD} + V_L}{V} * 100\% \quad (1)$$

Where: φ_T— total porosity of reservoir , % ; V — total rock volume, m^3 ;

V_{BD} — matrix cave pore volume, m^3 ; V_L — fracture volume, m^3.

When there is a fracture in the reservoir, the electrical resistivity logging interpretation model should be a parallel conduction model for two kinds of rock with single pore structure [5]. That is, the fracture in the rock and the conductive network of the matrix cave are two independent systems in parallel, they obey the Arichie formula, but have different pore indexes. According to this model, the resistivity of pure rock with full water content is (formula 2):

$$\frac{1}{R_o} = \frac{1}{R_L} + \frac{1}{R_{BD}} \quad (2)$$

Where:

R_o — Pure rock resistivity with full water content ,Ω•m ;

R_{BD} — matrix cave pore resistivity, Ω•m ;

R_L — fracture resistivity.

BASING SINGLE LOGGING CURVE RECONSTRUCTION

The fracture of the formation is usually filled with the filling material, and the filling material connects the fracture and rock solid in the direction of the vertical fracture [6]. So when the sound wave arrives to the fracture, it does not need energy conversion or Acoustic bypass, it can go through the fracture in the filler directly. So acoustic logging can only shows the matrix cave pore, it cannot tell the fracture pore. The existence of fracture affects the resistivity of rock layers, after the same reference scale standardization, the fracture in the rock can be identified through the superposition of the resistivity curve calculated by apparent acoustic porosity and formation apparent resistivity response curve (overlapping drawing) [7].

The parameters are closed in the case of one hundred percent water content in formation pore. In the consolidated pure rock, there is the following relationship between porosity and acoustic time difference(formula 3):

$$\varphi_T = \frac{\Delta t - \Delta t_{ma}}{\Delta t_f - \Delta t_{ma}} \quad (3)$$

Where: a — apparent acoustic porosity of rock ;

Δt、Δt_f、Δt_{ma} — the time required for acoustic wave traveling per meter in the rock, in the pore fluid and in the rock framework.

The apparent resistivity of pure rock strata can be obtained combining with Archie formula and apparent resistivity index formula(formula 4) [8]:

$$R_z = \frac{abR_w}{S_w^n \cdot \varphi_a^m} \quad (4)$$

Where: S_w — water saturation ; R_w — formation water resistivity ;

a, b , m , n are constants.

For permeability sand layer, if the fracture growth is good, the resistivity value will be significantly lower, at this time, the resistivity of the apparent acoustic porosity is found to be higher than that of the true rock, and there is a positive difference between the apparent resistivity curves [9]. When the crack growth in general, the resistivity value will be significantly lower, the resistivity of the apparent acoustic porosity is different from that of the true rock resistivity. When the fracture development is poor, the apparent porosity is an upper limit value due to the parallax of the acoustic waves, that is larger than the true porosity of rock strata, and the apparent resistivity of pure rock strata is small, there is a negative difference between the apparent resistivity curves [10].

The logging curves between 1894.0～1899.6min figure 2 show that GR amplitude was significantly lower, we can determine that this layer should be sand layer, the good permeability of the stratum segment can be judged by the "positive amplitude difference" on the microelectrode in this section, and the measured resistivity value is low, it can be preliminarily judged the fracture in this formation develops well.

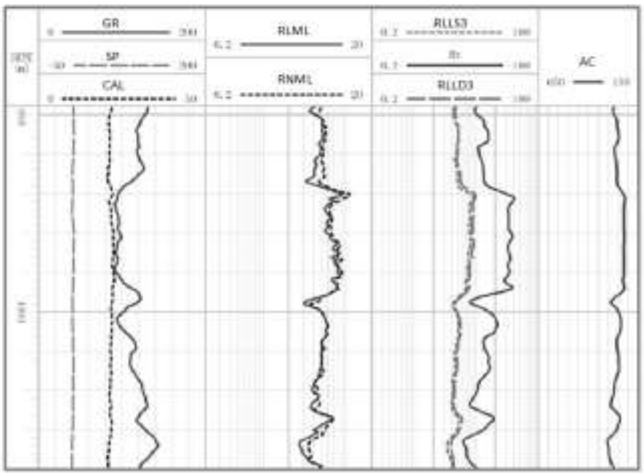

Fig-2: Overlap diagram of resistivity calculated by apparent acoustic porosity and formation apparent resistivity response curves (fracture develops well)

The logging curves between 1638.0～1644.8m in figure 3 show that because of the existence of the "positive amplitude difference", the permeability of this section is better, but there is no difference between the rock resistivity R_z and the three lateral curve calculated by the Archie formula, so the fracture in this formation develops generally.

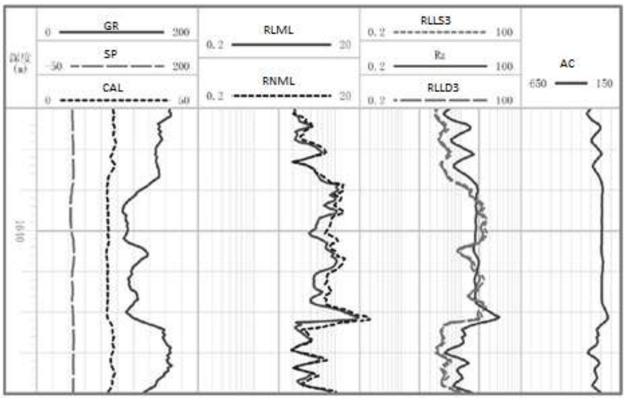

Fig-3: Overlap diagram of resistivity calculated by apparent acoustic porosity and formation apparent resistivity response curves (fracture develops generally)

The logging curves between 1638.0～1644.8m in figure 4 show that because of the existence of the "positive amplitude difference", the permeability of this section is better, but the resistivity of rock stratum is obviously at high value, preliminary judgment here cracks are not developed, the roughly assess is the fracture here doesn`t develop, and the difference of the rock resistivity Rz and the three lateral curves calculated by the Archie formula is negative, so the development of this stratum is poor.

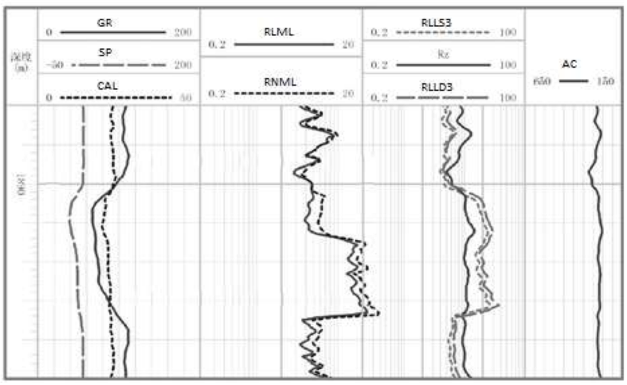

Fig-4: Overlap diagram of resistivity calculated by apparent acoustic porosity and formation apparent resistivity response curves (poor fracture)

BASING MULTIPLE LOG CURVE RECONSTRUCTION

The conventional logging curves are classified according to the nature of the influence of conventional well logging changes along with the fracture development. Multiply the numerical values of acoustic time (AC) and compensated neutron (CNL), and the value is the molecule of reconstruction feature curve (DACR); multiply the numerical values of bulk density (DEN) and deep and shallow lateral resistivity (RLLD , RLLS), and the value is the denominator of reconstruction feature curve (DACR) [4]; That is:

$$\mathrm{DACR} = \frac{\mathrm{AC}\cdot\mathrm{CNL}}{DEN\cdot\mathrm{RLLD}\cdot\mathrm{RLLS}} \quad (5)$$

The crack causes the volume density, the compensation neutron, the sound wave time difference as well as the deep, shallow lateral resistivity change in fracture development zone. These changes can be characterized by the difference between the curve filter and the original curve [6]. The conventional logging curves are filtered by 7 points, comparing them with the original conventional logging curves and calculating the relative amplitude difference of 5 kinds of conventional logging curves, the relative amplitude difference of conventional well logging curve and Structural reconstruction feature are used to identify fracture (formula 6) [8].

$$\mathrm{REMA} = \frac{|\mathrm{AC} - \overline{AC}|}{AC} + \frac{|CLN - \overline{CLN}|}{CLN} + \frac{|DEN - \overline{DEN}|}{DEN} + \frac{|RLLD - \overline{RLLD}|}{RLLD} + \frac{|RLLS - \overline{RLLS}|}{RLLS} \quad (6)$$

Where: AC, CNL, DEN, RLLD, RLLS — conventional well logging curves；
$\overline{AC}, \overline{CNL}, \overline{DEN}, \overline{RLLD}, \overline{RLLS}$— filtering curve of conventional well logging curve.

The design sketch of reconstruct characteristic curves shows the fracture in Fig. 5. The fracture develops well at the formation of 5296~5299m, 5301~5305m and 5309~5314m, the response characteristics are not clear in single logging curves, but they become clear after amplifying fracture response characteristics based on reconstructing curves (DACR, REMA) [10].

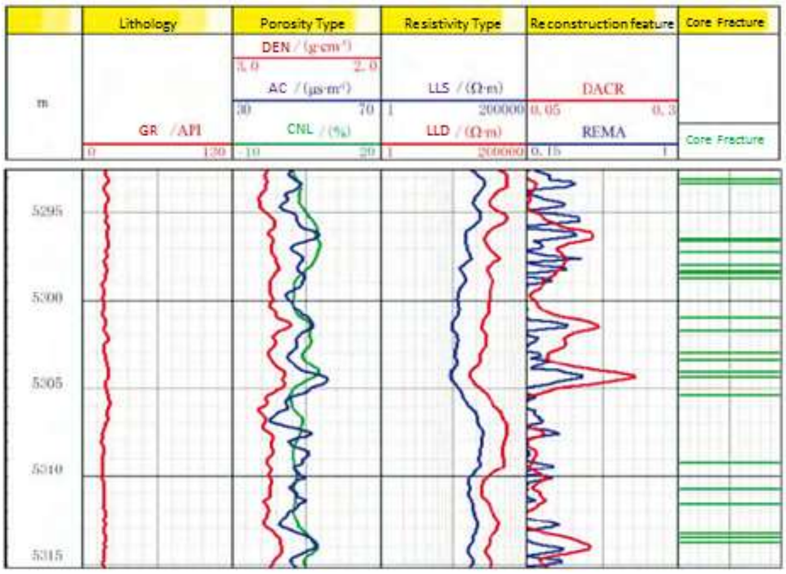

Fig-5: Identification of fractures using reconstructed log curves

CONCLUSIONS

According to the logging data, the fracture response characteristics of conventional logging curve elements are studied. The existence of fracture affects the resistivity of rock layers, after the same reference scale standardization, the fracture in the rock can be identified through the superposition of the resistivity curve calculated by apparent acoustic porosity and formation apparent resistivity response curve (overlapping drawing), this is basing single logging curve reconstruction to identify fracture. And if the single logging curve reconstruction cannot identify the fracture clearly in some formations, the multiple log curve reconstruction is another way (DACR, REMA).

REFERENCES

1. Bin, W., & Jianguoetc, P. (2013). Logging Interpretation Model Based on Dual Porosity Structure and Its Application. *Lithologic Oil and Gas Reservoir*, *25*(4), 68-72.

2. Feng, C. J., & Yan, W. L. (2013). Fracture Qualitative Identification Using Conventional Logging Data. In *Applied Mechanics and Materials* (Vol. 316, pp. 822-825). Trans Tech Publications.
3. Xiaoling, X., & Xiuju, J. (2015). Fracture Recognition Based on Multi Information Fusion of Conventional logging and Electric Imaging Logging. *Petroleum Geophysical Exploration, 50*(3), 542-547.
4. Min, W. (2010). Evaluation method of fractured reservoir based on two dimensional imaging logging. *China University of Petroleum (Hua Dong)*, 7-11.
5. Xia, H., Tuo, W., Guanjun, X. (2007). New biodegradation viscous crude oil source correlation method and its application. *Journal of special reservoirs*, *14*(5), 98-101.
6. Radke, M., Welte, D. H., & Willsch, H. (1982). Geochemical study on a well in the Western Canada Basin: relation of the aromatic distribution pattern to maturity of organic matter. *Geochimica et Cosmochimica Acta*, *46*(1), 1-10.
7. Luo, P., & Gu, Y. (2009). Characterization of a heavy oil–propane system in the presence or absence of asphaltene precipitation. *Fluid Phase Equilibria*, *277*(1), 1-8.
8. Deshi, G., & Jiayu, N. (1995). China unconventional oil and gas geology. *Beijing: petroleum industry press*, 30 - 60.
9. Jianzhong, Q., Zhiming, L., & Baoquan, L. (2007). High-quality Marine hydrocarbon source rock formation of heavy oil and solid bitumen potential analysis. *Geological oil experiment, 29*(3), 280-285.
10. Connan, J. (1984). Biodegradation of crude oils in reservoirs Anon. Advances in petroleum geochemistry. London: *Academic Press*, 299-335.