The dividing and value technique on well logs for Lithology identification of pyroclastic rocks

Linlin Dai $^{1,2}$, Lili Lin $^2$

$^1$ School of Earth Science, Northeast Petroleum University, Daqing, Hei Longjiang, 163318, China
$^2$ CNPC Logging company, Daqing, Hei Longjiang 163412, China

Abstract. The ability of logging curves to reflect the rock interface is related to logging principles, which is often different from the layer interface determined by coring. According to basic principle of logging curve, analyze the corresponding relationship between comprehensive lithologic boundary determined by coring and the boundary determined by well logging curve. The identification method combining the two technique is given. In view of that the logging curves are insensitive to some thin layers and transition lithology, the reasonable value method are given as a result. Using this result can well judge the change trend of lithologic profile.

Keywords: Dividing and value technique, lithologic profile, logging curve, layer rock Interface.

1. Introduction
The stratification value of logging data is closely related to its applications[1]. At present, logging stratification technology has been developed from manual mode to computer automatic realization stage[2-3]. Lin Haiyan etc.[3] have put forward an A well logging automated identification of rock boundaries method based on Warsh transformation. In the process of application, the cut-off frequency, moving window length and cut-off value of low-pass filtering are required to be designed for different logging curves, and the selection of these parameters is related to the structural parameters of the tool and the curve quality. Yan Jianping etc[4], used multi-log curve fusion method to overcome the limitation of the single curve in reflecting the actual geological conditions.

2. Principle of dividing logging curve for rock boundary
There are basically two kinds of stratification methods: one is simulated manual stratification methods (such as half amplitude point method, root 1/3 method, etc.), and the other is theoretical stratification methods (such as activity method, micro-quotient method, cluster analysis method, etc.).The hierarchical method in this paper combines the manual hierarchical method with theoretical hierarchical method. The basic principle of theoretical stratification is:

(1) Activity stratification. The activity method reflects the activity degree of a certain logging point. The activity value of the curve is calculated by using the standard activity function derived:
\[ A(d) = \left[ \tan^{-1} \frac{3E(d)}{n(n+1)(2n+1)} \right] \frac{B}{C_{L-R} M_{rev} D_{ps}} \]  

(1)

Where \( B \) is the track width of the logging plot, \( C_{L-R} \) is the absolute value of the left and right scale difference, \( M_{rev} \) is the sampling interval, \( D_{ps} \) is the distance of each depth unit on the curve, \( E(d) \) is the average amplitude of a curve composed of \( n \) sample points, \( n \) is the number of sampling points. In practical application, the activity value of mudstone was taken as \( \Sigma \). When \( A(d) > \Sigma \), the value of delamination was taken as 0.35 \( \Sigma \).

(2) Stratification of micro-business method. It reflects the characteristic pattern of log curve changing with depth. Each layer is assumed to show two features: ① if the average amplitude of a curve consisting of \( n \) points is compared to the average amplitude of adjacent intervals (also consisting of \( n \) points), their difference gets the maximum value across the interface. ② The difference between the two average mentioned above should exceed the threshold value at each interface. The expression is

\[
\begin{align*}
X_i = & \frac{1}{n} \left[ \sum_{j=i}^{i+n-1} Y_j - \sum_{j=i}^{i+n-1} Y_j \right] \\
X_k+i & \geq X_k > X_k-1
\end{align*}
\]

Where \( n \) is the number of sample points to be calculated, given according to the minimum stratification thickness and sampling interval, and is generally set as 4. \( X_i \) is the micro quotient value of the sampling point I.

3. Well logging stratification technology based on core data

In figure 1, the deep-lateral curve has 4 fluctuations from 1729.2m to 1732.4m, the corresponding mud logging profile also shows 4 layers, which are tuffaceous mudstone, tuffaceous siltstone, tuffaceous mudstone and tuffaceous siltstone respectively. The value point is chosen in each layer.

![Fig.1 Well logging curves are consistent with mud logging lithologic profile](image)

Lithology profile of a well includes coring section and non-coring section. Sometimes, lithology profile and well logging curves do not correspond to each other.
Case 1: The lithologic profile of coring section is finely divided, and is usually thinner than the vertical resolution of the deep laterolog. The comparison of longitudinal reflection capacity between coring section and deep-lateral curve is shown in figure 2. In figure 2, it is divided 11 layers by coring section from 1668m to 1671.4m, but the deep-lateral log curve only identifies 4 layers in the same interval. In view of this situation, the lithology of the thickest layer can be corresponded to the logging value of this layer because that the logging value is a comprehensive reflection of the log response of these layers. If the thicknesses of each layer are almost the same, the lithology of the middle layer is corresponded to it.

Fig. 2 Comparison of longitudinal reflection capacity between coring section and deep laterolog

Case 2: As shown in figure 3, in the non-coring intervals, using well logging data to divide layers gets better effect than using mud logging profile. In fig. 3, from 1615m to 1619.85m, there is only 1 layer in mud logging profile, but there are 7 layers divided by well logging data. In view of this situation, first of all, it should be considered that whether the changes of the curve are caused by fluid properties in different reservoirs, which can be determined by fluid occurrence in the mud logging lithologic profile. If fluid properties are different, oil-bearing correction should be conducted in the reservoir. Secondly, the comprehensive judgment should be made combining the porosity curve. Since the vertical resolution of the porosity curve is higher than the deep-lateral resistivity curve, if the porosity curve also presents a amplitude change, then the lithology of each layer is taken as the same value according to logging stratification.

Fig. 3 Using well logging data to divide layers gets better effect than using mud logging profile
4. Processing flow and effect analysis of integrated stratified of well logging and core data

4.1. Processing flow
Since there are many parameters of various curve value modes in the layered processing method, a processing interface is formed according to the following steps for convenient processing:
○ Input data;
○ Logging stratification;
○ Correction of surrounding layer[5];
○ Unified logging and logging interfaces;
○ Output data

4.2. Effect analysis
Considering all aspects of flexibility, universality and relevance in the process of stratify and value, good results can be obtained. The effect of stratify and value for Xi8 well in Daqing Oilfield is shown in fig. 4. According to the characteristics of various logging curves, the appropriate value method is adopted for each curve: LLD is used as the reference curve, using half amplitude point to stratify and extremum method to take value; For GR, combining geometric mean and extreme geometric mean to take value; for DT and CNL, combining geometric mean and area mean to take value; for DEN and PEF, using geometric mean to take value. The result is good and the boundary is fit from logging curve and core data.

5. Conclusion
In view of the fact that the exploration and evaluation wells can provide both logging lithologic profile and logging data, the stratify and value technology integrating mud logging data and well logging data is established. This technique uses a log curve with stable vertical resolution as the reference curve to determine layer boundary, which ensures the stratification value of other curves that are not sensitive to lithologic changes. In addition, the corresponding relationship between lithologic profile and layer boundary determined by well logging curves is fully considered, a unified layer boundary standard is established, to highlight the reflection ability of lithology on log curve, which is good for detailed evaluation of lithology and physical property of reservoir.

References
[1] YAN Limei, ZHOU Zhongyuan, XU Jianjun, et al. Research on the method of fault location of transmission device based on time series of alarm. Power System Protection and Control . Vol.46, No.7,Apr. 1, 2018,P38-48
[2] Xu, J., Huang, L., Yin, S. et al. All-fiber self-mixing interferometer for displacement
measurement based on the quadrature demodulation technique. Opt Rev. 2018, 25(1): 40-45.

[3] Xu Jianjun, Wang Bao’e, Yan Limei, et al. The Strategy of the Smart Home Energy Optimization Control of the Hybrid Energy Coordinated Control. Transactions of China Electrotechnical Society, 2017, 32(12): 214-223.

[4] Xu J.J., Gai D., Yan L.M. A NEW FAULT IDENTIFICATION AND DIAGNOSIS ON PUMP VALVES OF MEDICAL RECIPROCATING PUMPS. Basic & Clinical Pharmacology & Toxicology, 2016, 118 (Suppl. 1), 38-38

[5] Yang F, Yan L, Xu J, Li H. Analysis of optimal PMU configuration method based on incomplete observation. Concurrency Computat Pract Exper. 2018; e4835. https://doi.org/10.1002/cpe.4835

[6] Longchao, Zhu Jianjun, Xu; Limei, Yan. Research on congestion elimination method of circuit overload and transmission congestion in the internet of things. Multimedia Tools and Applications, Multimedia Tools and Applications, September 2017, 76(17), pp 18047–18066

[7] Nai-bo Zhang, Jian-jun Xu, Chen-guang Xue. Core-shell structured mesoporous silica nanoparticles equipped with pyrene-based chemosensor: Synthesis, characterization, and sensing activity towards Hg(II). Journal of Luminescence, 2011, 131(9): 2021-2025

[8] Yang Yong, Wu Mingtao, XU Jianjun. Arithmetic Based on Wavelet Transform and Process SVM for Automatically Identifying Log-curve Formation. Journal of Software Engineering, 2015, 9(3): 666-672

[9] Yan Zhang, Jianjun Xu, Limei Yan. The Multi-objective Model of Congestion Eliminating Method of Interruptible Load Nodes. International Journal of Future Generation Communication and Networking, Volume 9, No. 10, October 2016.

[10] Lei Shi, Jianjun Xu, Limei Yan. The Research on network Losses Allocation of Power Market based on Improved REI Network Numerical Equivalence. International Journal of u-and e-Service, Science and Technology, Volume 9, No. 11, November 2016.

[11] YAN Limei, XIE Yibing, XU Jianjun, et.al. Improved Forward and Backward Substitution in Calculation of Power Distribution Network with Distributed Generation. JOURNAL OF XI‘AN JIAOTONG UNIVERSITY, 2013, Vol.47, No.6, p117-123. (In Chinese)

[12] Yan Limei, Zhu Yusong, Xu Jianjun,et.al. Transmission Lines Modeling Method Based on Fractional Order Calculus Theory. TRANSACTIONS OF CHINA ELECTROTECHNICAL SOCIETY, 2014 ,Vol.29, No. 9:260-268 (In Chinese)

[13] YAN Li-mei, CUI Jia, XU Jian-jun,et.al. Power system state estimation of quadrature Kalman filter based on PMU/SCADA measurements. Electric Machines and Control. 2014, Vol.18 No.6,: 78-84. (In Chinese)

[14] Xu, Jianjun, Xu, Aihua, Yan, Limei, et al. Grids state estimation of quadrature Kalman filter based on PMU/SCADA. Energy Education Science and Technology Part A: Energy Science and Research, 2014, 32(2): 1033-1038