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Log Data Used to Predict Coal Reservoir Permeability: A Case Study from the Yanchuannan CBM Field, China

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Abstract

Coalbed methane (CBM) reservoir permeability is a key parameter to affect the productivity of CBM Wells, and its accurate acquisition has always been one of the most crucial problems in CBM reservoir evaluation. Given the common methods measuring the permeability, well test analysis performs a poor result for the low permeability reservoir in china, and cores measurement in laboratory is usually restricted by the sample scale. Geophysical well logging is an important method for CBM reservoir evaluation. Not only could the log data be utilized to analyze the coal structure but also to indicate the distribution of CBM reservoir permeability by analyzing the response between the log information and the coal structure.

Therefore, the NO.2 coal seam of Shanxi formation is selected as the research object in Yanchuannan CBM field, Ordos basin and coal core and logging data from 37 parameter wells are collected to compare and analyze the numerical response relationship between coal structure and logging curve shape characteristic in NO. 2 coal seam, according to the results of which, the caliper (CAL), density (DEN), natural gamma (GR), depth lateral resistivity (LLD), shallow lateral resistivity (LLS) and the variance between LLS and LLD (LLD-LLS) are chosen as the optimized log response assemblage to identify the coal structure. Based on Bayesian Discriminate Analysis method, the log data responding coal structure identifying model is established to predict the distribution pattern of the NO.2 coal seam structure in the study area. Additionally, 162 CBM Wells production data are collected to calculate the CBM reservoir permeability and then establish the permeability distribution pattern of No.2 CBM reservoir.

By comparing and analyzing the correlation between coal structure and coal reservoir permeability in the study area, the conclusions can be obtained as follows:

(1) According to the coal structure calculation results from 37 wells, the coal structure in the study area could be divided into 3 different types, i.e. Type I (original-textured coal),Type II (ruptured coal) and Type III (grated coal), and they present pretty good correspondence relationship with the log curves(Fig1,Fig2).

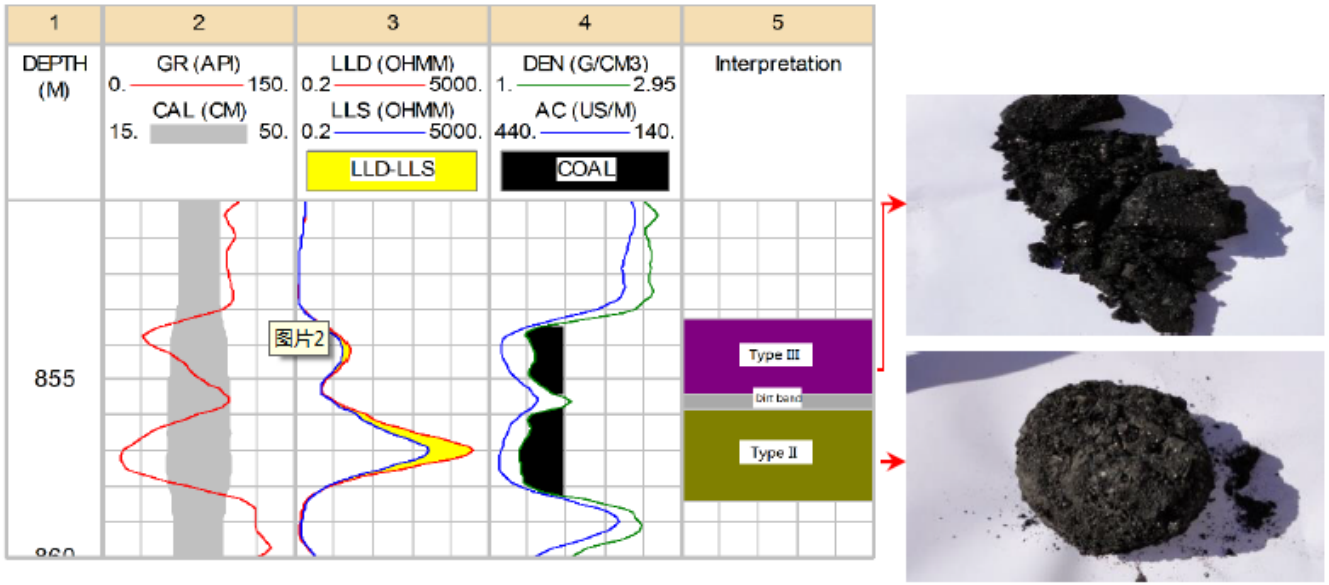

Fig. 1. The Y1-52-38U well's response relationship between log curves and coal structure of NO. 2 coal seam.

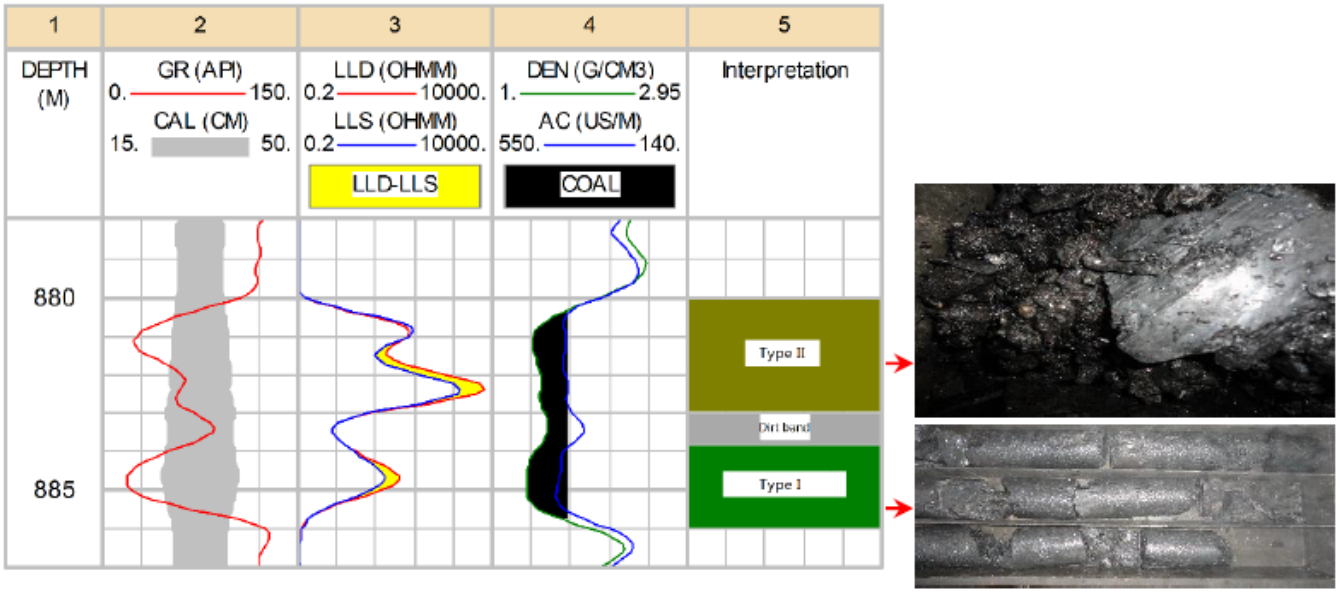

Fig. 2. The Y5-V1 well's response relationship between log curves and coal structure of NO. 2 coal seam.

(2) In this study, CAL, DEN, GR, LLD, LLS and the variance between LLS and LLD are selected as the best logging data response assemblage to construct the coal structure model combining with Bayesian Discriminant analysis technique.

(3) According to the Bayesian Discriminant (Table 1), three types coal structure model responding to log data has been constructed:

Coal Type I

Y1=100.2530*CAL+128.4930*DEN-41.7390*GR+1014.9380*LLD-385.5210*LLS+1563.7250*（|LLD-LLS|）-355.0250；

Coal Type II

Y2=96.2520*CAL+130.0960*DEN-34.3340*GR+972.8160*LLD-353.1560*LLS+1517.1770*（|LLD-LLS|）-347.0040;

Coal Type III

Y3=99.0890*CAL+153.9450*DEN-57.9040*GR+1022.7790*LLD-373.8220*LLS+1543.1200*（|LLD-LLS|）-372.9470;

Logging suite	Bayesian Discriminant equation coefficient		
	Type I (original-textured coal)	Type II (ruptured coal)	Type III (grated coal)
CAL	100.2530	96.2520	99.0890
DEN	128.4930	130.0960	153.9450
GR	-41.7390	-34.3340	-57.9040
LLD	1014.9380	972.8160	1022.7790
LLS	-385.5210	-353.1560	-373.8220
|LLD-LLS|	1563.7250	1517.1770	1543.1200
Constant term	-355.0250	-347.0040	-372.9470

Table 1. Bayesian Discriminant equation coefficient.

(4) The coal reservoir permeability distribution has a positive correlation with coal structure and can be predicted indirectly by the coal structure model. The Type I (original-textured coal) represents the higher permeability range, Type II (ruptured coal) is medium and Type III (grated coal) stands for the lower.