Comparison and analysis of the organic carbon content model of source rock in the calculation of well logging data

Chuanbao Yang [1], Chunsheng Yang [2], Liyan Yang [1]

[1]College of Earth Sciences, Northeast Petroleum University, China

[2]Research Institute of Exploration and Development of Daqing Oilfield Company Ltd

Abstract

According to theoretical analysis and the shortage of Δlog R in the baseline, background value of organic carbon content, overlap coefficient K, maturity parameter. We deduced improved Δlog R model. According to the improved Δlog R model, we propose stepwise regression mode. Then we compare three models, we find stepwise regression mode is the best, In the evaluation of regional organic carbon content, based on sedimentary facies zoning evaluation. At the same time, we put forward some matters needing attention in the application of the model, method for calculating organic carbon content in well logging methods in the future.

Keywords

logging, hydrocarbon source rock, organic carbon, stepwise regression, log R, improvement, preferred

1. Introduction

The abundance of organic matter in source and estimation and evaluation of oil and gas reserves in the basin has a very important position[1].In the past, the content of organic carbon was mainly depended on the geochemical analysis and testing method,evaluation results are affected by analytical sample representation[2].According to the well logging data, the organic carbon content in the vertical distribution can be obtained,weaken the limited core samples for analysis of statistical error brought by the factors such as random sampling.Organic carbon in rock can lead to many kinds of logging response[3,4].To accurately calculate the content of organic carbon in source rock, it is necessary to combine many kinds of well logging information.

2. Model analysis and comparison

2.1 Δlog R model

Deficiency of logR model:

Baseline value:The calculation of log R depends on the baseline value,a well usually has multiple baseline values， need to determine appropriate baseline values based on experience,subjective factors have a greater impact.

Background value of organic carbon content:Calculation of TOC need to add the background value of organic carbon content,the range of background value of organic carbon content is larger,not easy to determine.

Overlap coefficient K:Under the condition of unknown source rock logging response characteristics, advanced given overlap factor,it is not objective.

Maturity parameter:Maturity parameter selection is not at that time,calculation of the absolute content of organic carbon will produce the overall error,it has certain non applicability

2.2 Improved log R model

Based on the principle of Δ log R method, an improved Δlog R model is derived.

(1)Baseline value:No need to read the baseline value,can be quickly calculated

Δlog R.

Background value of organic carbon content Δ TOC:The background value of organic carbon content is related to the sensitivity of organic carbon logging response,it can be determined by the method of function fitting.

Overlap coefficient K:On the one hand, the overlap coefficient plays a role in the effect of porosity on the logging response of organic carbon,on the other hand, the ability to recognize kerogen and hydrocarbon fluids is restricted.

Maturity parameter:Because there are many baseline values in a well,so it needs to establish the relationship between the well and the interpretation.The content of organic carbon in source rocks is closely related to the logging response of gamma, density, neutron and so on.

3. Example comparison and analysis

3.1 Data selection and preprocessing

There is a certain error between the depth and the actual depth of the samples,the development of organic carbon has strong heterogeneity,these two factors increase the difficulty of establishing the model with higher credibility.The data of organic carbon analysis used in this paper are core data and sampling density,it is an ideal layer of organic carbon log interpretation model.

3.2 Comparison and analysis

Table 1 TOC calculating results from three different models

Basin well number	logR		Improved logR		Quadratic stepwise regression	
	R	SE	R	SE	R	SE
Hailaer Wu 23	0.805	0.520	0.809	0.521	0.921	0.343
Hailaer Bei 10	0.640	0.801	0.719	0.723	0.875	0.504
Hailaer Bei 35	0.595	0.384	0.596	0.384	0.824	0.270
Songliao Jin 87	0.736	0.476	0.814	0.408	0.890	0.320
Songliao Jin 88	0.798	0.773	0.798	0.772	0.862	0.651
Songliao Yu 17	0.540	0.873	0.692	0.787	0.898	0.477

Using Δlog R model, the improved Δlog R model and stepwise regression model were used to calculate the organic carbon content of source rocks.Statistical analysis of the three models of organic carbon and the analysis of correlation between the degree of R and the standard error SE.(Table 1)

The greater the R, the higher the degree of correlation between organic carbon and measured organic carbon,the smaller the SE, the smaller the calculation of organic carbon and the analysis of the deviation of organic carbon. Therefore, the greater the SE, the smaller the R, the more reliable the calculation results.The results from the three models are easy to see. Quadratic stepwise regression model to calculate the effect of organic carbon content is better than the other two models.

(1)Comparison of logR model and improved logR model

Can be seen from the table 1,Wu 23 well, Bei 36 well,Jin 88 well,Δlog R model and improved Δlog R model calculation results are quite; Bei 10 well,Jin 87 well,Yu 17 well,the improved Δlog R model is better than the Δlog R model.

(2)A comparison between the progressive regression model and the improved logR model

Data from table 1 is easy to see, stepwise regression model of each well calculated the effect of organic carbon content was better than the improved Δlog R model, Wu 23 well, Bei 35 well,Yu 17 well especially evident. Statistical analysis of well logging parameters in the stepwise regression model for each well(Fig.2)The following two aspects: the model parameters selection and parameter combination of aspects of the comparative analysis of progressive regression model is better than the reasons for the improvement of the model.

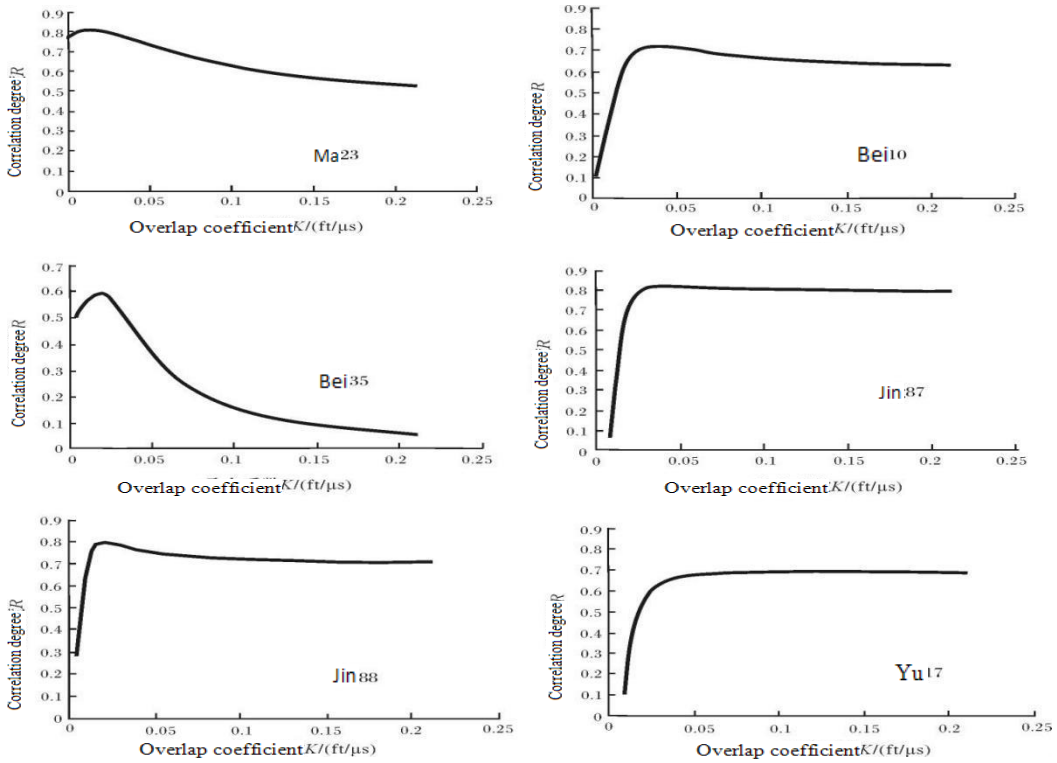

Fig. 2 Correlation coefficient between Δlog R and measured TOC and its variation with superposition coefficient K for different wells

Table 2 Parameters in Stepwise regression equations

Parameter	Wu 23	Bei 10	Bei 35	Jin 87	Jin 88	Jin 17
sonic					√	
resistance	√					
gamma	√	√				√
density	√				√	
neutron					√	√
Sonic * sonic		√		√		
Sonic * resistance						
Sonic * gamma					√	
Sonic * density				√		
Sonic * neutron	√				√	√
Resistance * resistance	√	√		√		

Resistance * gamma				√		
Resistance * density					√	
Resistance * neutron						√
Gamma * gamma	√	√		√		√
Gamma * density				√	√	
Gamma * neutron						
Density * density	√				√	
Density * neutron						
Neutron * neutron	√					√

Logging parameter selection

From the view of a single well,the regression equation of each well has the gamma, density, neutron,especiallyWu 23 well,Yu 17 well，the regression equation of the two wells contains the gamma, density, and the number of parameters of the neutron respectively accounts for 75% and 100% of all the parameters in the regression equation;Overall,table 2 statistical parameters,found containing gamma, density, neutron parameters of 75% of all parameters,description of gamma, density, neutron, the organic carbon content of the response is obvious.Gamma parameter, in particular,six wells with four wells gamma parameters in the form of the two party directly in the equation,the remaining two wells are in the form of the combination of parameters in the form of gamma,that GR can be a good reflection of the organic carbon content.It is supposed to be an effective parameter to calculate the content of organic carbon.The improved R log model does not consider the gamma, density, neutron, so the calculation of organic carbon content is less than the stepwise regression model.

Combination of well logging parameters

From the view of a single well,the combined parameters are larger in the regression equation of each well,the overall combination parameters of 71.8% of all parameters.It shows that the combined parameters can reflect the organic carbon content more than the single well logging parameters,stepwise regression model to calculate the effect of organic carbon is better than the improved Δlog R model.

4. Conclusion

Log R model operating process is cumbersome, subjective factors, and is not convenient, not objective and not applicable.

The improved log R model is the same as the log R model,ignore the gamma, density, seed and other parameters,there are still deficiencies.

The stepwise regression model takes into account various logging parameters and the combination of various parameters. The method is objective, theoretical analysis and practical examples show that the model is better than the other two models.

Reference

[1] Zhang Zhiwei,Zhang Longhai,A method of source rock evaluation by well-logging and its application result[J].Petroleum Exploration and Development,2000,27(3):84-87

[2]liu Junmin,Peng Ping'an,Huang Kaiquan,et al,An improvement in CARBOLOG technique and preliminary application to evaluating organic carbon content of source rocks [J]. Geochimica, 2008, 37(6):581-586

[3]Zhang Xiaoli,Sheng Ying.Study on the source rock of Jurassic coal measure strata in Tulufan-Hami Basin by logs[J].Well Logging Technology,1998,22(3):183-185

[4]Zhang lipeng,Bian Ruixue,Yang Shuangyan,et al.Identifying hydrocarbon source rock with log data [J].Well logging Technology,2001,25(2):146-152