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Hydrocarbon Generation Potential of the Upper Palaeozoic Coal Measure Source Rocks in Su11 Block

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Abstract. Based on the analysis of regional geological background, relevant work is carried out through experimental testing, logging evaluation, and reservoir forming characteristics analysis and drilling productivity statistics. The analysis shows that the residual organic carbon content of the Upper Paleozoic coal measure source rocks in the Su 11 block ranges from 40.86% to 70.75%, and the residual organic carbon content of the dark mudstone ranges from 0.51% to 26.80%. The organic matter is mainly composed of vitrinite and inordinate with carbon isotope ranging from -24.81 ‰ to 22.64 ‰ and type 3. The vitrinite reflectance distribution of source rocks is between 1.2% and 2.1%, and is in the mature-high maturity stage. The total gas generation intensity of source rocks is between (10-50) × $10^8 m^3$ and km^2. The plane shows "strong north weak" Tight sandstone gas migrates into the reservoir through "near source", and the gas source conditions have significant control over the gas reservoir distribution.

1. Introduction

Su-11 block is an important area for the exploration of dense sandstone gas in Sulige gas area, this area is located in the northwest of Sulige gas field, the northwest side of changing Jungian gas field of Sulige temple area. The north is about 50km from the front of the etok, and the east is about 65km from the national flag, and the north and south are about 33km long. The east is about 19km wide and the exploration area is $620km^2$. Nowadays, the structure is a large monoclinic with low northeast and southwest high, and the local structure is seldom developed, and there is no obvious fracture structure development. The forming conditions of dense sandstone gas in this area are similar to that of Sulige. The main purpose layer is also stone box group and Shanxi group, the gas source rock formation is Shanxi group, Taiyuan group and Benxi group, the tectonic morphology has no obvious control effect on gas reservoir distribution. Area is drilling and more than 400 at present, and the northern region has entered the development phase, the density of drilling up to 1 km x 1 km, and central and southern low degree of exploration, drilling scarce, there has been no big breakthrough in the exploration aspect, which is to the key object to expand in the field of exploration. , The Paleozoic hydrocarbon source rocks in sulige gas field were evaluated by predecessor but it is limited to some high degree exploration areas, the understanding of Sue 11 block hydrocarbon source rock is weak, systematically evaluation of the hydrocarbon source rocks in the su11 block is the necessary work to explore the advantageous new area.

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2. Geochemical indicators of gas hydrocarbon source rocks

Through the experiment testing and logging data of the evaluation of hydrocarbon source rocks, upper Paleozoic geochemical indicators, the samples are from s11-27-24, s11-31-38, s11-36-73, s11-31-70, s11-30-70, s11-30-70, s6-2-26c6, a total of 6 drilling Wells were collected, and 83 samples were collected, and 584 tests were carried out on TOC, chloroform asphalt "A" extraction and isotopes.

2.1. Organic abundance of hydrocarbon source rocks

The organic heterogeneity of the upper Paleozoic source rocks in the su11 block is obvious, reflecting the test results are widely distributed of TOC, S1+ S2, chloroform asphalt "A", the average difference between different levels was obvious (Table 1) The specific distribution features following: the distribution interval of the dark mudstone TOC was 0.51%~ 26.8%, the average of different layers is between 3.60% ~ 5.91%. The distribution interval of S1+S2 is 0.13mg/g~20.26 mg/g, and the average value of different layers is between 2.26mg/g~5.09 mg/g. The distribution interval of chloroform asphalt "A" is 0.001%~ 0.071%, and the average value of different layers is between 0.030% ~ 0.034%. According to the evaluation standard of organic matter abundance of coal-bearing source rocks established by Huangdi Fan (1995), the organic matter abundance of dark mudstone in this area is medium-good level. Coal is recognized as a high quality gas source rock. The average TOC of coal rock is 60.58%, the average value of S1 + S2 is 36.06mg / g, and the average of "A" of chloroform bitumen is 0.055%.

Table 1. Organic matter abundance of sourcr rocks in Upper Palaeozoic of Su 11 area

Source rock type	Layers	TOC/%	S_1+S_2/(mg/g)	Chloroform bitumen A /%	Overview
dark colour mud rock	Shanxi group	0.51-26.80 5.91/19	0.18-20.26 5.09/19	0.001-0.051 0.030/7	Medium - good
	Taiyuan group	0.71-7.79 3.60/17	0.25-6.59 2.26/17	0.005-0.071 0.034/17	Medium
	Benxi group	0.55-25.31 4.79/20	0.13-8.95 2.85/13	0.002-0.071 0.031/19	Medium - good
coal	Upper Palaeozoic	40.86-70.75 60.5/8	15.11-57.01 36.06/8	0.051-0.064 0.055/6	

2.2. Source rock organic matter type

Organic matter type is one of the important parameters to evaluate hydrocarbon generation ability of source rocks. The origin and thermal evolution of organic matter in source rocks affect the determination of their types, which generally require the mutual identification of multiple geochemical indicators to accurately identify parent types. According to kerogen microstructure identification of kerogen type is more intuitive, the source area of the study area kerogen microstructure triangle diagram (Figure 1a), the kerogen mainly consists of vitrinite and inordinate, and the type of kerogen is mainly type 3. The carbon isotopic value of kerogen is less affected by the degree of thermal evolution, which is especially suitable for distinguishing the organic matter types of mature source rocks. The kerogen Root carbon isotope results showing (Figure 1b), δ13C all distributed between -24.81 ‰ ~ 22.64 ‰, according to the previous establishment of the division criteria [1, 2], kerogen type belongs to type 3. According to the comprehensive analysis, the organic matter types of the source rocks in the study area are mainly Type 3, which is in agreement with the predecessors [3].

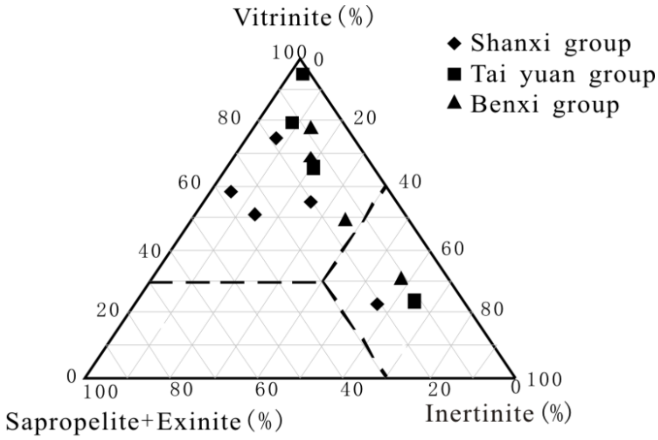

Figure 1a kerogen microstructure triangle

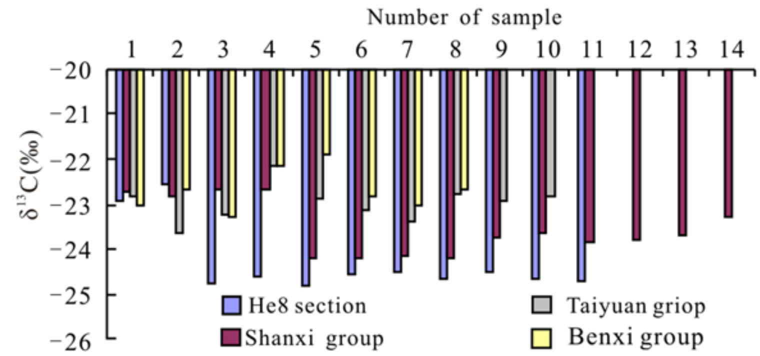

Figure 1b Kerogen δ13C distribution histogram.

Figure 1. Organic carbon type of source rocks form upper Palaeozoic of Su 11 area

2.3. Source rock maturity

The vitrinite reflectance (Ro) of cores from Block Su 11 was distributed between 1.2% and 2.1%, reaching maturity and high maturity. Vitrinite reflectance (Ro) characterizes the maturity of hydrocarbon source rocks as the most classical, which is irreversible with depth and temperature evolution. In addition, structural inversion has not been experienced since the Upper Paleozoic strata were deposited and the heat flux is relatively stable. Therefore, we can deduce the current Ro value at any depth according to Ro-buried depth (Fig.2).

Figure 3 shows the upper Palaeozoic Ro contour obtained from the above method. The depth of the map is the average buried depth at the base of Shanxi Formation to that of Benxi Formation. The results show that the Ro in the northeast is relatively low and increases toward the southwest, northeast low, high southwest regional tectonic setting.

3. TOC logging evaluation of coal measure source rocks

Because the well log values are the comprehensive response of rock strata, the influencing factors are multifaceted. Therefore, it is necessary to comprehensively consider the logging curves of organic carbon content and mutual verification to reliably identify the source rocks in the coal strata and accurately evaluate them.

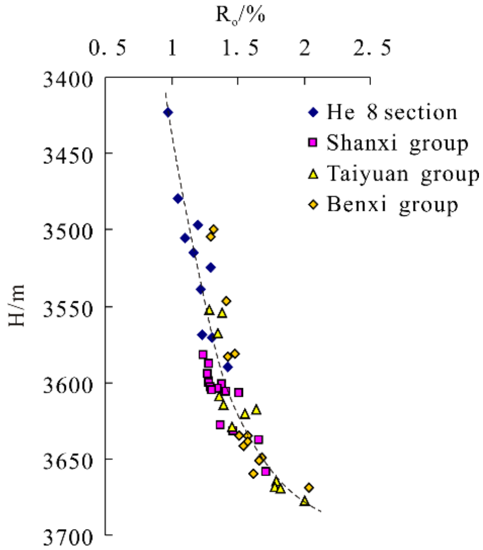

Figure 2. Source rock Ro and depth relationship

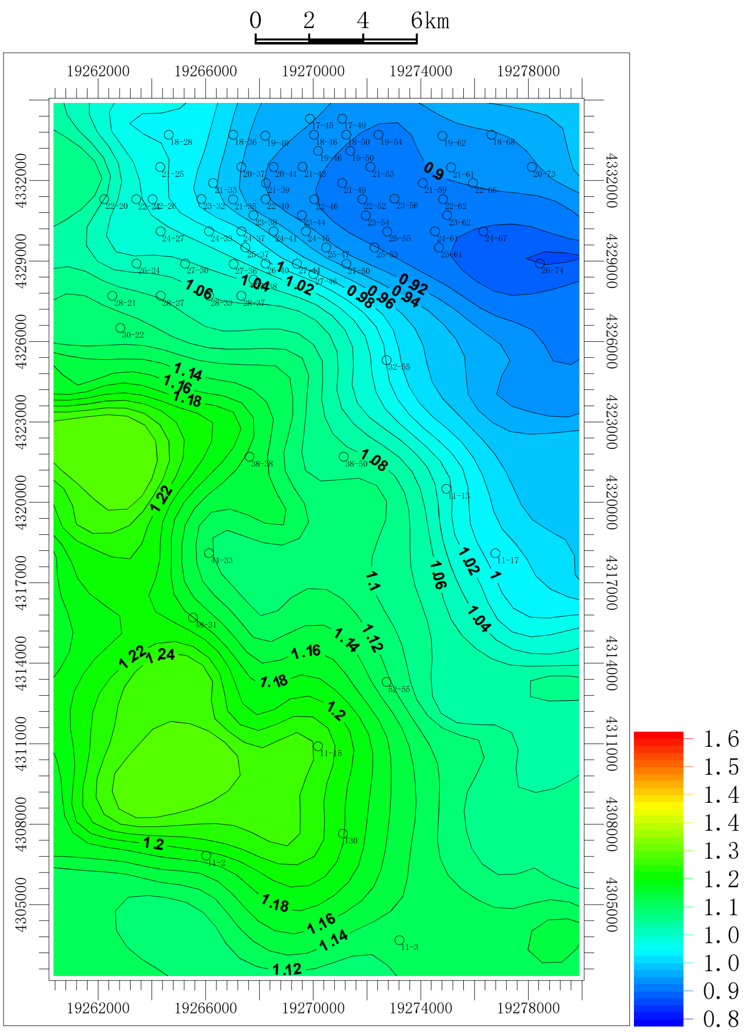

Figure 3. Source rock Ro plane distribution

The TOC is larger than the other two indexes and the stability of the experimental test is good. Therefore, TOC is the preferred index to evaluate the organic matter abundance of source rocks in this area. As mentioned earlier, the TOC content in source rocks fluctuates significantly. It is not objective to use only a few measured TOC values to represent the hydrocarbon generation capacity of the whole strata. This method cannot be achieved with the lack of measured TOC data in most wells. In response to this challenge, TOC logging evaluation technology of source rock is introduced. TOC of shaly source rock is predicted by the improved ΔLgR technique [4]. Based on the measured parameters in the TOC calibration model, the well prediction formula Continuous distribution of TOC values in the profile (Figure 4). Completed the TOC logging prediction of muddy source rocks in more than 400 wells in the whole area, based on this, the contour map of TOC in the Upper Palaeozoic dark mudstone was obtained by calculating the average and the difference between wells. The contour maps of different horizon TOC can also be calculated according to this method.

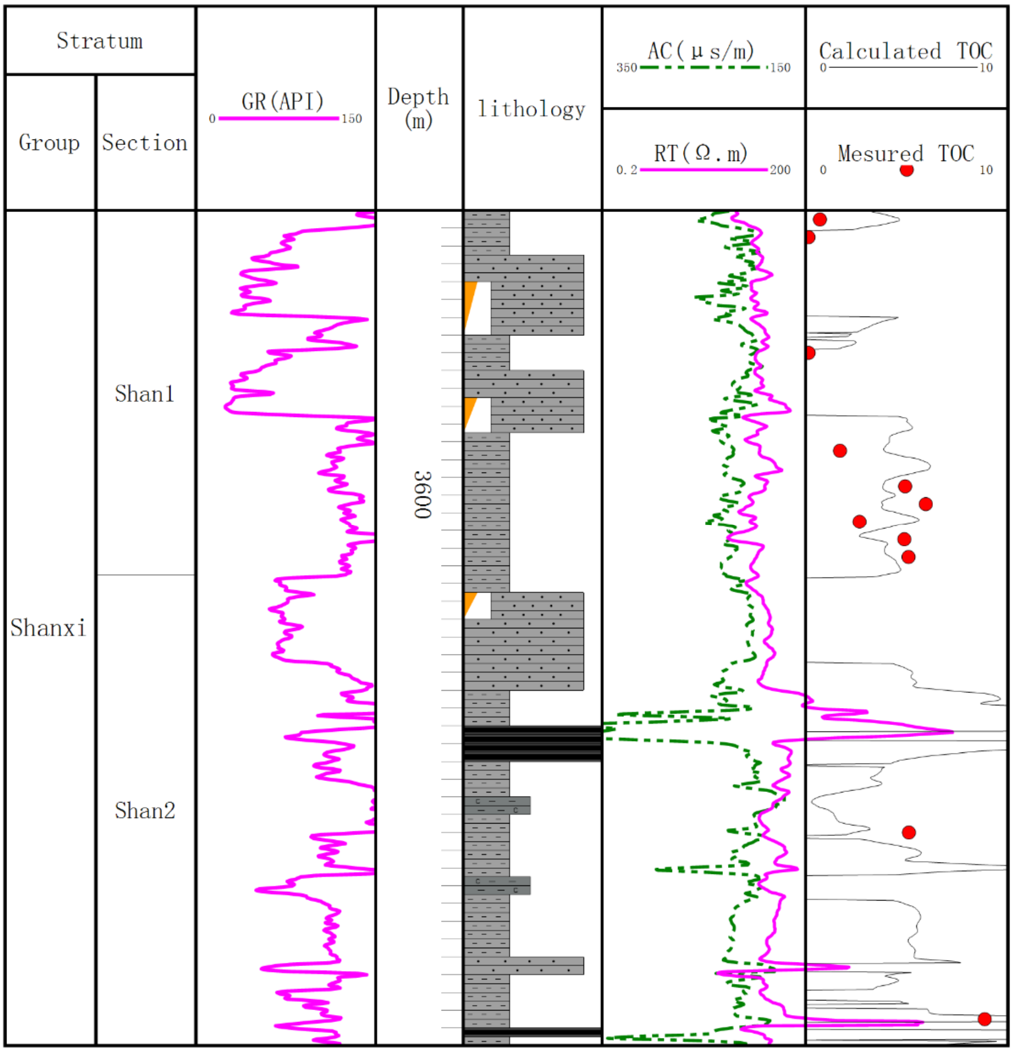

Figure 4. TOC logging evaluation results of the Palaeozoic muddy source rocks in the Upper Su-11 block

4. Evaluation of Hydrocarbon Generation Potential in Different Lithologies of Upper Palaeozoic Coal Measures Source Rocks in Su 11 Block

The pros and cons of source rock gas supply conditions are affected by the quality and development of source rock itself. The influence of both on the source rock gas supply conditions can be mainly reflected as the intensity of source rock gas generation. The gas generation intensity of the Upper Paleozoic source rock is calculated by "Organic Carbon Production Rate Method", and the mathematical model is as follows:

$$G=H\times\rho\times TOC\times r\times f\times 10^{6}$$

In the formula, G is the source rock gas intensity, $10^8 m^3 / km^2$. H is the thickness of the source rock, m; ρ is the density of the source rock, t / m^3; TOC is the present residual organic carbon content (%); r is the recovery factor of the original organic carbon; f is the cumulative gaseous hydrocarbon yield, m^3 / (t.TOC). The results of hydrocarbon generation (Fig. 5) show that the gas-generating intensity of source rocks in the Su-11 block ranges from (10-50) × $10^8 m^3 / km^2$. It is roughly equivalent to the previous prediction that the intensity of anomaly in the whole area of Sulige (10 ~ 40) × $10^8 m^3 / km^2$ [5]. In combination with the gas production data of the development well, it can be seen that the high gas generation intensity range of the Upper Palaeozoic coal measure source rock has a higher degree of well matching with the high gas well productivity. Taking the northern part with more drilling as an example, The production of gas wells with gas intensity greater than 30 × $10^8 m^3 / km^2$ in this area is generally 1132 ~ 6990 × $10^4 m^3$, The average output is 2658 × $10^4 m^3$, and the proportion of high-yield gas wells (output higher than 3500 × $10^4 m^3$) reaches 23%. Gas wells with gas intensity of 10 ~ 30 × $10^8 m^3 / km^2$ have a gas production of 223 ~ 4301 × $10^4 m^3$ with an average of only 1520 × $10^4 m^3$. The gas generation intensity in well X11-23-56, X11-21-59 and X11-22-62 is less than 20 × $10^8 m^3 / km^2$ and the average gas production is 538 × $10^4 m^3$, which is obviously lower than the average level . It can be seen that the gas production capacity of this area is obviously controlled by hydrocarbon source rocks, so it is highly reliable to predict the favourable area of the coal source rock in the upper Palaeozoic.

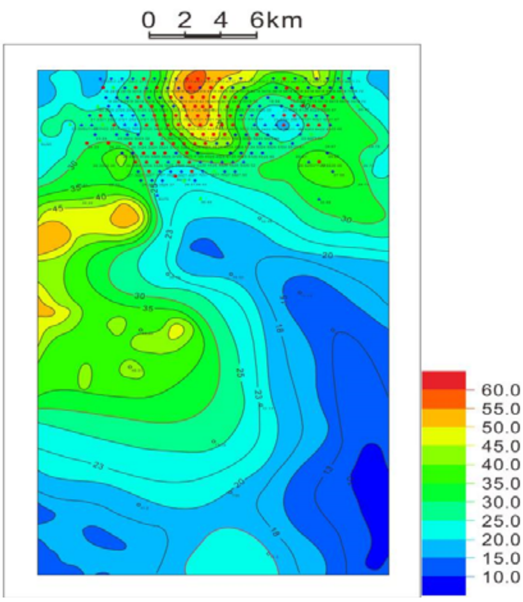

Figure 5. The gas intensity contour map of the upper Palaeozoic source rocks and the favourable area of the tight sandstone gas exploration

5. Conclusion

(1)The upper Palaeozoic gas source condition is superior to the Su 11 block, the organic matter is 3 typewhichis in mature ~ high mature evolution stage, the gas production intensity is between (10 ~ 50) $\times 10^8 m^3/km^2$.

(2)Using the improved ΔLgR technique to predict the TOC of the argillaceous hydrocarbon source rock, the effect is better.

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