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The application of cracking coefficient method to the study on fractures in volcanic of Anda area

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Abstract. According to the actual situation of volcanic reservoirs in Anda area, this paper uses the comprehensive analysis of drilling and logging data to predict the fracture development of volcanic reservoirs in the study area. Among them, the ratio of longitudinal wave velocity, “crack coefficient” method, is used to analyze and calculate the crack development frequency. The research shows that the fractures of volcanic reservoirs in Anda area are relatively developed, and the characteristics of fracture parameters will inevitably affect the exploration and production of natural gas in this area.

1. Regional geological characteristics

Anda area is located in the north of Xujiaweizi fault depression. It is a NNW-trending depression. The western part of the basin is controlled by faults and the eastern part is overlap. The lithology of volcanic rocks in the third member of Yingcheng formation in this area are mainly rhyolite, yinganite, andesite and basalt. The ds3 block takes the middle basic volcanic rocks, namely andesite and basalt, as the main lithology and reservoir. The ws1 block takes acid volcanic rocks, namely rhyolite, as the lithology and reservoir. The pore types are mainly pore, micro-pore, feldspar dissolution pore, volcanic ash dissolution pore, fracture and micro-crack produced by the devitrification of rhyolitic glass in spheroidal rhyolite. The cracks and micro-cracks here are not only primary, but also secondary and generated by structure. Because of the variety of pore types and the influence of cracks and micro-cracks on reservoir physical properties, they are also found in Anda area. It is the main migration channel and reservoir space of natural gas in this area. It has certain significance and reference value for this research.

2. The principle of cracking coefficient method

Crack density is a quantitative index for evaluating the degree of fracture development in rocks. Fracture density of rocks exposed on the surface is easy to be directly counted, but it is very difficult to obtain data of fracture density in underground rocks. The development frequency of reservoir fractures in Anda area was evaluated by the "crack coefficient" method used in Japan in the 1970s for the evaluation of surrounding rock stability of underground engineering [1] [2].

The spread of seismic wave velocity and lithology, porosity, pore fluid types, rock fracture, buried depth and so on many factors, the same compressional wave velocity of rock is related to the full extent of the rock. Among them, the p-wave velocity passing through the intact rock is faster, while that of the non-intact rock is slower. In particular, the p-wave velocity of the rock significantly decreases when high-angle fractures are developed in the rock. For volcanic rock formation, high

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Angle, in the development of structural fracture condition are the main factors influencing the p-wave velocity, therefore can make use of the ratio of p-wave velocity of the growing degree of the evaluation of rock pore, and make a crack in the rock coefficient and the known drilling, through this fitting relationship purpose of the study of volcanic rock fracture. Crack coefficient method of expression is:

$$S = C_p/C_{ma} \quad (1)$$

S for cracking coefficient; C_p is the p-wave velocity of rock, m/s; C_{ma} is the p-wave velocity of rock skeleton, m/s.

In order to make the method of tortoise cracking coefficient applicable to reservoir fracture analysis, the relationship between tortoise cracking coefficient and fracture development degree is improved according to reciprocal relationship between wave velocity and acoustic time difference, changed the type (1) is:

$$S = (\Delta t_{ma}/\Delta t_p) \quad (2)$$

Δt_{ma} for rock skeleton longitudinal wave acoustic time, μs/m; Δt_p for rock p-wave acoustic time, μs /m.

The S is larger, the closer the acoustic time difference of the rock is to that of the rock skeleton, indicating that the integrity of the rock is better. Is the larger the fracture development gap, is the smaller the fracture development frequency. Is the smaller S, is the more serious the rock damage, is the smaller the fracture development gap, and is the greater the fracture development frequency.

The crack spacing and crack coefficient and may produce unit length (m) may develop cracks in the article number is as follows:

when $S > 0.75$, crack spacing greater than 80 cm, fracture frequency is less than or equal to 1.25 / m; When $0.65 \leq S \leq 0.75$, the crack spacing is 60-80 cm, fracture developing frequency of 1.25-1.75 / m;

When $0.55 \leq S \leq 0.65$, the crack spacing is 40-60 cm, fracture developing frequency of 1.75-2.5 / m;

When $0.45 \leq S \leq 0.55$, the crack spacing is 20-40 cm, fracture developing frequency of 2.5-5.0 / m;

When $S < 0.45$, crack spacing is less than 20 cm, fracture frequency is greater than 5 / m.

3. Evaluation and results

According to the drilling core data in Anda area, to attribute the drill in volcanic rocks can be divided into five kinds, respectively is rhyolite and tuff, dacite, andesite and basalt, of different lithology select appropriate frame parameters is the key to successful evaluation of reservoir fracture, therefore on the basis of previous studies using the "log element capture spectroscopy (ECS)" volcanic rock skeleton parameters (table 1) [3].

Tab.1 Matrix parameters of volcanic rock

Rock type	density（g/cm^3）	longitudinal wave acoustic time（μs/m）	longitudinal wave velocity（m/s）
rhyolite	2.4	182	5500
tuff	2.4	143	7000
dacite	2.45	162	6250
andesite	2.5	200	5000
basalt	2.8	156	6410

In this way, the "crack coefficient" method is applied to calculate and analyze the fracture development frequency of volcanic rock reservoir in the third section of Yingcheng formation of 20 wells of ds3 block and ws1 block in Anda area (table 2).

Tab.2 Fracture developing frequency in volcanic of Anda area

block	well	S	crack spacing（cm）	crack frequency（A/m）
ds3	ds1	0.49	28	3.57
	ds3	0.60	50	2.00

	ds301	0.53	36	2.78
	ds302	0.65	60	1.67
	ds5	0.59	48	2.08
	ds6	0.61	52	1.92
	ds7	0.76	＞80	＜1.25
ws1	ds2	0.56	42	2.38
	ds4	0.65	60	1.67
	ds401	0.67	64	1.56
	ds8	0.88	＞80	＜1.25
	ws1	0.63	56	1.79
	ws101	0.91	＞80	＜1.25
	ws102	0.72	74	1.35
	ws 903	0.68	66	1.52
	ws 905	0.54	38	2.63
	ss1	0.65	60	1.67
	ss102	0.54	38	2.63
	ss2	0.60	50	2.00
	ss5	0.38	＜20	＞5.0

4. Conclusions

From the map of contour map of fracture development in Anda area (figure 1) [4-6], we found that the most developed fractures are at the southeast of the study area and the least part at the northwest. This area is mainly controlled by Xu fault in the West and Xudong fault in the southeast. For this reason, secondary structural fractures in this area, together with primary micro-fractures, constitute an important migration channel and reservoir space for natural gas in this area. The application of "tortoise cracking coefficient" combined with drilling and logging data can predict the plane development of cracks in Yingcheng Formation volcanic reservoir in Anda area, which is basically consistent with the actual situation. Therefore, the study of fractures and micro-fractures has certain guiding significance and reference value for the exploration and production of natural gas.

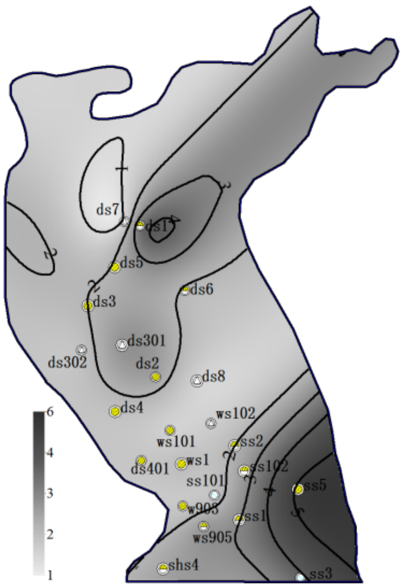

Fig.1 Fracture development contour map in Anda area

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