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The analysis of characteristics of reservoir brittleness of down ES^4 of the Damingtun Depression

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Abstract: The oil shale of the down area ES^4 in the center Damingtun Depression which is wide distribution and large thickness. The ES^4 depression is the most important source oil rocks and has a good tight oil reservoir, what is the key area of tight oil exploration and development in Liaohe Depression. The key factors affect the fracture extent of tight oil reservoir rock and mining effectiveness is the brittleness of rock. By transverse and longitudinal wave sonic logging data to calculate the object of the study area tight oil reservoir horizon dynamic style modulus and Poisson's ratio dynamic, application Rickman rock brittleness index calculation formula to calculate the tight oil reservoirs brittleness. On this basis, Damintun Depression ES^4 tight oil reservoirs in the oil shale carbonate quality oil shale, silty shale, siltstone and shale lithology dolomites five kinds of brittleness analyzed establish superiority brittleness index lithologic sequences. The results show that the best index of brittleness shale dolomite, the brittleness index greater than 40 accounted for 92.43%. It is advantageous purpose layers of dense oil Hirai fracturing.
Keywords: The Damingtun Depression; ES^4; tight oil; brittleness of rocks.

INTRODUCTION

The tight oil is another new hot spot after shale gas in global unconventional oil and gas exploration and development [1-2], which is named as "black gold" in oil industry [3]. China started exploration tight oil is late, and tight oil concept has been widely accepted and adopted in recent years. The Liaohe oilfield has increased exploration research and deployment efforts of tight oil and gas in recent years, and achieved significant exploration results, exploration of oil and gas in a number of areas has made an important breakthrough. The tight oil reservoirs are low porosity and permeability, fracture development degree system has an important influence on hydrocarbon accumulation and development [4], the rock brittle is the key factor in fracture extent of tight oil reservoir. In this paper, acoustic logging shear and compressional wave data combined Rickman to calculate rock brittleness index formula, and get the Damintun depression ES^4 sequence of PS3, PS2 and PS1 tight oil reservoirs brittleness index[5]. While establishing tight oil reservoir lithology advantage brittleness index series, provide a reference for the dense water Hirai perforation position.

MINERAL BRITTLENESS CALCULATION METHOD

Flexible parameter method [6] is used to test of various parameters and measure to characterize of the brittleness rock; these parameters include strain, tensile and compressive strength, internal friction angle, indentation hardness, etc. We can get rock mechanics parameters measurement results by experiments, calculate rock Young's modulus and Poisson ratio and evaluate the brittleness rock. It is believed that the higher Young's modulus and the lower Poisson ratio will result higher brittle rock. Due to the high cost and long period of the experimental rock mechanic, we can calculate the dynamic Young's modulus and dynamic Poisson's ratio by conventional shear wave and longitudinal wave acoustic logging data [7]. We get the conventional shear wave and longitudinal wave acoustic logging data of Shen 352 Well and calculate the tight oil reservoirs of down ES^4 dynamic Young's modulus and dynamic Poisson's ratio in Damintun Depression (Fig 1). Computation formula is the following:

Dynamic Young's modulus: $E_d = \frac{\rho}{\Delta ts^2}\left(3 - \frac{\Delta tc^2}{\Delta ts^2 - \Delta tc^2}\right)$; Dynamic Poisson's ratio: $\mu_d = \frac{2 - \frac{\Delta ts^2}{\Delta tc^2}}{2\left(1 - \frac{\Delta ts^2}{\Delta tc^2}\right)}$

In Formula: Δts, Δtc—Shear slowness and compressional slowness, μs/m; ρ—Media volume density, g/cm^3

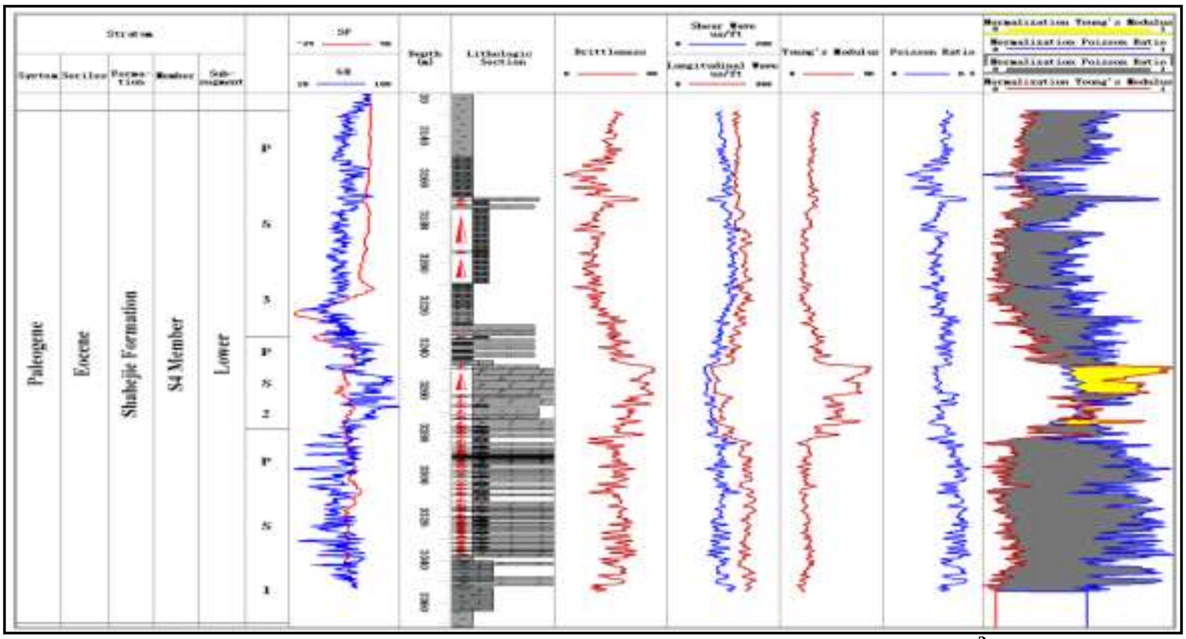


Fig-1: Dynamic Young's modulus and Poisson's ratio of tight oil reservoir in the down $S4^2$ section in Damintun Depression

Rickman [8] proposed a method of calculating the brittleness of the shale in 2008, the method is based on the statistical analysis of the data of the shale in North America, the Young's modulus of shale distribute during 1~8GPa, the Poisson's ratio distribute during 0.15~0.4. Calculate the average normalized Young's modulus and Poisson's ratio to get brittle index. The study calculated the basis of dynamic Young's modulus and Poisson's ratio, through the calculation formula of Rickman the brittleness of the shale, and we get the Damintun depression down ES^4 tight oil reservoirs brittleness index (Fig 1). The calculation formula is as follows:

$$YM\_BRIT = ((YM\_C - ym\_min)/(ym\_max - ym\_min)) \times 100$$

$$PR\_BRIT = ((PR\_C - pr\_min)/(pr\_max - pr\_min)) \times 100$$

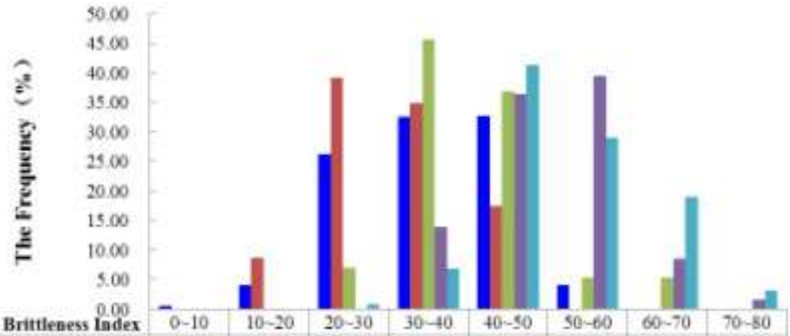
$$BRITavg = (YM\_BRIT + PR\_BRIT)/2$$

YM_C, PR_C are Young's modulus and Poisson's ratio;
ym_max, ym_min are the maximum and minimum Young's modulus;
pr_max, pr_min are the maximum and minimum values of Poisson's ratio;
YM_BRIT, PR_BRIT are the brittleness of Young's modulus and Poisson's ratio;
BRITavg is the index of rock brittleness.

Comprehensive Analysis, we conclude overall brittleness of tight oil reservoirs in down $S4^2$ is good, and distribution is between 20 and 70. Among them, the brittleness of PS1 sequence and the PS2 sequence is better than the PS3's. It is because that the PS3 sequence mainly developed with large sets of oil shale and siltstone, but PS1 sequence and PS2 sequence is full of siltstone, carbonate oil shale and argillaceous dolomite. PS2 sequence has a large index of rock brittleness mainly greater than 40 because of a large segment of argillaceous dolomite. This facilitates the development of tight oil reservoir cracks and micro-cracks, and improves the reservoir performance.

ADVANTAGES BRITTLENESS ROCK ANALYSIS

We get an evaluation of tight oil reservoir lithology of brittleness in the Damintun Depression down $S4^2$ (Fig 3), there are mainly 5 kinds lithology of brittleness indexes and from good to bad are muddy dolomite, siltstone, silty shale, carbonate oil shale and oil shale.



The Brittleness Index	0~10	10~20	20~30	30~40	40~50	50~60	60~70	70~80
The oil shale	0.45	4.04	26.23	32.51	32.74	4.04	0.00	0.00
The carbonate oil shale	0.00	8.70	39.13	34.78	17.39	0.00	0.00	0.00
The silty oil shale	0.00	0.00	7.02	45.61	36.84	5.26	5.26	0.00
The siltstone	0.00	0.00	0.00	13.95	36.43	39.53	8.53	1.55
The argillaceous dolomite	0.00	0.00	0.78	6.79	41.25	28.98	19.06	3.13

Fig-2: Distribution histograph of different lithology Brittleness in the down $S4^2$ section in Damintun Depression

Argillaceous dolomite has a best of brittleness, and its brittleness index is in more than 40 accounted for 92.43%. The brittle indexes of siltstone and silty oil shale are mainly distributed in 30~60, accounting for 89.92% and 87.72%, respectively. Carbonate oil shale and oil shale brittleness is relatively poor, carbonate oil brittle range from 20 to 50, accounting for 91.3%. Oil shale is distributed between 10~60.

CONCLUSION

- The overall brittleness of tight oil reservoir in down $S4^2$ of the Damingtun Depression, mainly distributed 20 to 70. The brittleness of PS2 sequence is highest, mainly bigger 40. This facilitates the development of tight oil reservoir cracks and micro-cracks, and improves the reservoir performance.

- The establishment of brittle index sequence of tight oil reservoir in the down $S4^2$ of the Damingtun Depression. There are mainly 5 kinds of indexes in tight oil reservoir and from good to bad are muddy dolomite, siltstone, silty shale, carbonate oil shale and oil shale.

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