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The Improvement of Predicting Method in the Displacement Pressure of Fault Rock and Its Application

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Abstract:- In order to evaluate lateral sealing of fault more accurately, based on the previous study of predicting method in the displacement pressure of fault rock, in view of the existing problems of predicting method in the diagenetic compaction depth of fault rock, based on the thought that the diagenetic compaction grade of fault rock should be equal to the diagenetic compaction grade of a shallower depth of surrounding rock getting prediction of the diagenetic compaction depth of fault rock, improved the predicting method in the displacement pressure of fault rock, and applied it in evaluating fault lateral sealing of f-np5-2 fault to 1~7 reservoirs in lower of Ed_3 in Nanpu 5 structural zone of Nanpu depression in Bohai Bay Basin. The result indicates that the minimum displacement pressure of fault rock in 1,2,3,6 reservoirs of f-np5-2 fault are all bigger than the displacement pressure of reservoir rock.. They are sealed laterally, for drilling shows oil layer. The minimum displacement pressure of fault rock in 4,5,7 reservoirs of f-np5-2 fault are all smaller than the displacement pressure of reservoir rock. They are not sealed laterally, for drilling shows water layer. It indicates that the method is feasible to evaluate lateral sealing of fault, and compared with the previous method, not only prediction principle is more conformer to the geological law, but also the evaluation results are accord with oil-gas drilling results.

Key words: *fault rock; the displacement pressure*

I. THE IMPROVED FAULT PREDICTION METHOD OF FAULT ROCK DISPLACEMENT PRESSURE

The fault prediction method principle is regarded as strata that dip in surrounding rock strata composed of fault rock formation. It can be used to study the displacement pressure of fault rock in accordance with the method of surrounding rock displacement pressure. Due to the displacement pressure of surrounding rock is easy to get from laboratory testing, and its value and the size of the compaction diagenetic depth (if the overlying formation does not exist obvious erosion, can be replaced by current buried depth) and shale content has a function relationship in formula 1.So as long as the compaction diagenetic buried depth of fault rock and shale content can be curtained, the displacement pressure of fault rock can be determined through formula 1.

$$Pd = ae^{bZR} \qquad (1)$$

in formula(1):Pd—Displacement pressure of surrounding rock, MPa;

Z—Buried depth of surrounding rock, m;

R—Shale content of the surrounding rock, decimals;

a、b—Constants related to the region.

The shale content of fault rock can be regarded as the sum of argillaceous components that glide the studied breakpoint, which created by each set of sand shale formation broken and fallen into the fault zone. It may be obtained by the shale content prediction method [14] of fault rocks that proposed by Yieding (formula (2)).

$$R_f = \frac{\sum_{i=1}^{n} h_i R_i}{L} \qquad (2)$$

in formula(2): R_f—The fault rock shale content, decimals;

h_i—the stratum thickness of the i rock layer that fractured by fault, m;

R_i—the shale content of the i rock layer that fractured by fault, decimals;

n—The number of layers that fractured by fault, i=1,2， ……n;

L—fault displacement, m.

Fault rock compaction diagenetic depth should be comprehensive reflection by the degree of compaction diagenetic; mainly by its diagenetic compaction pressure and compaction diagenetic time these two factors. Usually the greater the compaction diagenesis is, and the longer time the fault rock compaction diagenetic is, the buried depth is larger. The opposite is smaller. Only when fracture stop activities, can fault rock compaction diagenetic under the impact of overlying sedimentary loading, its compaction diagenetic time (T_f can be fault activity stop time to so far) significantly later than its compaction diagenesis time of surrounding rock with the same depth (T_s is the time for the start date of deposit to so far).The diagenetic compaction pressure (formula 3) should also be less than its surrounding rock diagenetic compaction pressure with the same depth(formula 4).By supposing the ratio of fault rock diagenetic compaction pressure and compaction diagenesis time is equal to the ratio of the same depth surrounding rock, the compaction diagenetic buried depth of fault rock was derived ,as shown in formula 5.

$$N_f = \rho_r Z_f \cos\theta \qquad (3)$$

$$N_c = \rho_r Z_c \qquad (4)$$

in formula(3,4): Z_f—fault rock compaction diagenetic buried depth, m;

Z_c—surrounding rock compaction diagenetic buried depth, m;

θ —fault dip,°;

ρ_r —sedimentary rock average density, g/cm^3;

N_f—fault rock compaction diagenetic pressure, MPa;

N_c—compaction diagenetic pressure of the same depth surrounding rock, MPa.

$$Z_f = \frac{T_f Z_c}{T_c \cos\theta} \qquad (5)$$

in formula(5): T_f—fault rock compaction diagenetic time , Ma；

T_c—compaction diagenetic time of the same depth surrounding rock, Ma；

Z_f， Z_c， θ have the same meaning as item.

Finally plug the above identified value R_f and Z_f in formula 1, then calculated the displacement pressure of fault rock.

II. THE IMPROVED FAULT ROCK DISPLACEMENT PRESSURE PREDICTION METHOD

In conclusion, when calculating the fault rocks buried depth, the former method is to assume that the ratio of the fault rock diagenetic compaction pressure and the compaction diagenesis time equals with the ratio of the same depth surrounding rocks. It is lack of theoretical basis, even the ratio of the two equal, it may also just be a special case of the relationship, do not provided with universal rule. Then the value of Z_f calculating by formula 5 may cannot truly reflect the fault rock compaction diagenetic buried depth, the calculated displacement pressure of fault rock also cannot necessarily accurately reflect the sealing capacity, this may bring risk evaluation of lateral sealing ability of fault. Therefore, to obtain the accurate displacement pressure of fault rock, it is essential to improve the prediction methods. As you can see from figure 1, if the fracture in depth Z_0 stop activities and start to compaction diagenetic, the compaction diagenetic degree should be significantly less than the degree of its surrounding rock compaction diagenetic with the same depth, but should be greater than Z_0 surrounding rock's diagenetic compaction degree, and should equal to a certain degree between them. From this, we can gain formula 6.

$$N_f T_0 = N_s T_s \quad (6)$$

in formula(6)： T_0—time that fault stop act and begin to compaction diagenesis, Ma;

T_s—surrounding rock compaction diagenetic time that have the same compaction diagenetic degree with fault rock, Ma；

N_s—surrounding rock compaction diagenetic pressure that have the same compaction diagenetic degree with fault rock, MPa；

N_f, has the same meaning as item.

Substitute formula 3 and $N_s = \rho_r Z_s$ into formula 6 and we can get the fault rock compaction diagenetic buried depth, as formula 7.

$$Z_f = \frac{T_s Z_s}{T_0 \cos\theta} \quad (7)$$

in formula(7)：Z_s—surrounding rock compaction diagenetic buried depth that have the same compaction diagenetic degree with fault rock, m;

T_s、T_0、θ have the same meaning as item.

By the formula 7, you can see that, to know the compaction diagenetic depth of fault rock Z_f, T_s, Z_s, T_0 and $\cos\theta$ must be known, and T_s, Z_s is unknown. A equations has two unknowns, under normal circumstances is unable to solve, but through the test values method: first given a Z_s value, T_s value can be determined by the relationship between the thickness and time of the stratum, then plug in formula 7 and determined a Z_f. Whether the Z_f is fault rock compaction diagenetic buried depth or not, basically depends on whether the value meet the $Z_0 < Z_f < Z$ or not, if satisfied, Z_f is the fault rock compaction diagenetic buried depth, on the contrary, if the value does not meet the $Z_0 < Z_f < Z$, so it is not fault rock compaction diagenetic buried depth. Then give Z_s a given value, repeat the above calculation, until found all the value of Z_f that meets the $Z_0 < Z_f < Z$ condition. From that, the compaction diagenetic depth of fault rock may not be a fixed value, should be a range, the range may be different to the same fault at different breakpoint, but the lower limit is a fixed value, its value can be obtained through formula 8, which comes from assuming that the fault rock diagenetic compaction degree and Z_0 diagenetic compaction degree of surrounding rock is equal.

$$Z_{f\min} = \frac{Z_0}{\cos\theta} \quad (8)$$

As we know the fault rock compaction diagenetic minimum buried depth, substitute it and the determined shale content of fault rocks into formula 1 ,then, the fault rock minimum displacement pressure value can be computed, we can use this value to evaluate the lateral seal ability of faults.

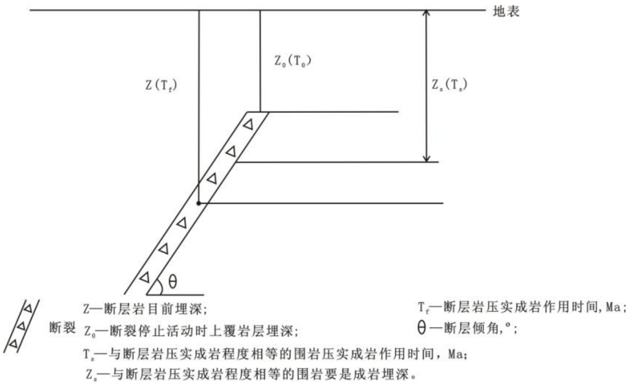

Fig.1 the required parameters relationship diagram of predicting the diagenetic compaction depth of fault rock

III. APPLICATION INSTANCE

This article selects Nanpu sag of Bohai bay basin tectonic 5 f-np5-2 faults as an example, the former and after improvement of fault rock displacement pressure prediction methods respectively to predict its 1-7 at the bottom of the east three minimum displacement pressure in fault rocks, reservoir and the reservoir rock with the oil and gas in disk displacement pressure compare with lateral sealing ability of the fault of the evaluation results and has found the analysis of the relationship between oil and water distribution, verified the improved displacement pressure of fault rock displacement pressure of fault rock before forecasting method is improved prediction method used in the lateral sealing ability of fault evaluation more reasonable.

Due to the f-np5-2 fracture in the late Ming town group sedimentary stop activities, fault rock began to compaction diagenetic, so the fault rock compaction diagenetic time T_f group shall be the Ming town, deposition to the end of today's time, about 2 Ma, the surrounding rock buried depth Z_0 related to it is about 1080 m, formula 8 can be used to obtain the minimum fault rock compaction diagenetic buried depth, it is about 1163 m. Use the fault displacement of f-np5-2 at the bottom of the fracture in east three (about 90 m) and its fault broken strata thickness, shale content (available natural gamma curve data obtained by formula 9), the f-np5-2 fracture in east three sections of the lower 1-7 shale content of fault rock reservoir can calculated, between 84% and 95%, respectively, as shown in table 1.Substitute the determine fault rock compaction diagenetic minimum depth and the 1-7 reservoir shale content into formula 1, the f-np5-2 fracture fault rock minimum displacement pressure in east three lower sections of 1-7reservoir can be calculated, respectively 0.62-0.71 MPa. Put the buried depth and shale content (can be gained from natural gamma curve data obtained by formula 9, respectively between 12.98%-51.44%, as shown in table 1) into formula 1 ,and calculated the 1-7 reservoir rock displacement pressure, respectively 0.61-1.42 MPa, , as shown in table 1.Compare f-np5-2 fracture in the east reservoir in three sections of the lower 1-7 fault rock minimum displacement pressure and displacement pressure of the reservoir rock of the relative size, you can see that 1, 2, 3, 6 reservoir in f-np5-2 minimum displacement pressure value rupture fault rocks are greater than the displacement pressure value of the reservoir rock, fault lateral seal, NP503 well drilling for oil and gas are reservoir at present. And reservoir 4, 5, and 7 f-np5-2 minimum displacement pressure value rupture fault rocks are less than that of displacement pressure value of the reservoir rock fault lateral which is not closed, the current NP503 drilling for oil and gas layer.

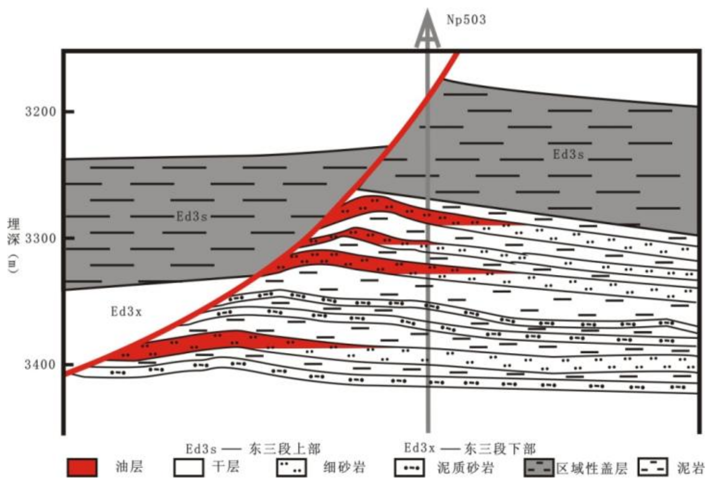

Fig.2 oil-gas profile in the lower of Ed3 of low plate of f-np5-2 fault in5 structural zone of Nanpu sag

$$R = \frac{2^{GCUR \cdot I_{GR}} - 1}{2^{GCUR} - 1} \quad (9)$$

$$I_{GR} = \frac{GR - GR_{min}}{GR_{max} - GR_{min}}$$

in formula(9)：R—shale content of oil and gas reservoir rocks, decimals;

GR—natural gamma value of oil and gas reservoir rocks;

GR_{max}—mudstone natural gamma value;

GR_{min}—Sandstone natural gamma value;

GCUR—Parameters related to the formation of experience, new stratigraphic is 7, old stratigraphic is 2;

I_{GR}—Natural gamma-ray relative value.

If using the improvement methods (formula 5) to calculate f-np5-2 rupture at the bottom of the east three sections 1-7 compaction diagenetic reservoir buried depth of about 333.51 m, the value and f-np5-2 fracture in east three sections of the lower 1-7 reservoir shale content in fault rocks (table 1) in formula 1 f-np5-2 can be calculated from fracture in the east reservoir in three sections of the lower 1-7 displacement pressure of fault rock 0.29 0.31 MPa, respectively, as shown in table 1, are less than 1-7 of displacement pressure of the reservoir rock, fault lateral is not closed, it inconstant with the result of current NP503 Wells in the 1-7 reservoir of oil and gas drilling. Although the former improvement methods in the literature [9]-[11] example application effect is good, but this example application effect is not good, may indicate the method of use is not widespread.

IV. THE CONCLUSION

The improved fault rock displacement pressure prediction method for fault prediction principle of compaction diagenetic buried depth is much conform to the compaction diagenetic law of sedimentary rock than before, the prediction got a range of the fault rock compaction diagenetic values, it given the exact minimum value, rather than the former method that predict a fixed fault rock value. The former is much conforms to the underground compaction diagenetic characteristics of fault rock than the latter.

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