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The experimental study on displacement pressure in fractured reservoir of Mudstone

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Abstract: The closure of fractured mudstone is resulted from the deformation under the changing of stress condition, also decreased the permeability of formation, as well as shrinking the production of oil and gas wells to zero. The focus of the study is how to quantify the effect of stress change on crack closure, and the selection of the appropriate characterization parameters. We see from the obvious level, the fractures of mudstone are influenced by the change of stress, the most apparent change among parameters is the formation permeability. If we make the permeability as the parameter to characterize the degree of mudstone fracture closure, then the concentration should be the specific value we quantified to distinguish the stress leading to closure in this value, it is what my research would focusing on. In this essay, we have stimulated underground fractured mudstone conditions by artificial fracture to study the natural core of mudstone, also applied the method of displacement pressure with the experimental study of mudstone fracture closure.

Key words: *mudstone; fractured reservoir; displacement pressure; closure pressure*

There are many countries in the world of basins and regions have found the shale fractured oil and gas reservoirs of industrial value. Such as the United States, Canada, Russia, the United Kingdom, etc. Among them, the United States and Russia are the main countries in the exploration and development of oil and gas reservoirs. They found earlier, a wider range as well as a higher yield. In eastern China: Bohai Bay, Songliao, Jianghan, Nanxiang, Subei basin; western: Chaidamu, Tuha, Jiuquan, Zhun Ger, Tarim Basin; Central: Sichuan Basin, all found industrial oil and gas or oil and gas shows in argillaceous rock fracture traps. The middle piece of Gulong depression is located in the central depression area of Songliao Basin, Songliao Basin sits in the northeast part of China, the acreage is about $28.7\times10^4 km^2$. In depression the Qingshankou Formation deposited a thick set of mudstone (280~520m), Intercalated psammite rocks while the mudstone is rich in organic matters, the type of parent materials is kerogen type Ⅰwhich means it belongs to the high maturity stage, it is one of the major oil supply areas in Daqing placanticline, for further studying the mudstone fractured formation mechanism of Qingshankou formation. In this paper, the method of displacement pressure is used to study the fractured mudstone reservoir.

I. EXPERIMENTAL PRINCIPLE

In the process of forming oil and gas reservoirs, mudstone has the feature of different composition structure and low porosity and permeability which are different from sandstone, commonly used as cap rock. And it has the function of trapping oil and gas reservoirs. As affected by the stress change in the geological history, some mudstone formation formed into cracks (Fig.1), and oil and gas migrated and stored within it, making mudstone itself possesses a certain capacity of storage. Speaking of the mining of oil and gas in fracture, we need to take the dynamic characteristics of mudstone fractured reservoir and sandstone porosity reservoir into account. Among them, the closure of the mudstone cracks is one of the important differences.

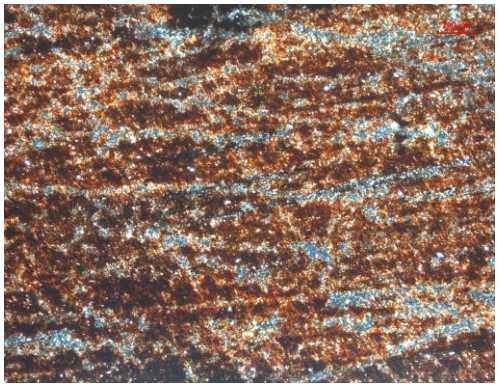

Fig.1 The microscopic picture of zonal distribution in the fractured core

Before the Oil and gas are mined, the fluid pressure in the cracks keeps the balance with the pressure of the fluid in the crack and the formation pressure (external pressure) of the surrounding rock, oil and gas can not be flow arbitrarily. When the oil and gas in the cracks flow into the wellbore flow, flow pressure gradually decreased, the original pressure of formation keeps stable, then pressure difference is formed .On one hand, the existence of pressure difference making fluid to consistently flow along the crack to the wellbore, on the other hand the increase of pressure difference making the change of the stress distribution of rock and cracks. The rock and crack deformed into closure. The mudstone is kind of plastic elastomer, when the deformation caused by the stress reached the plastic deformation, even if the stress is unloaded, the closure of mudstone fracture will still be difficult to restore.

The key to study the closure pressure of mudstone fracture is: finding a parameter which could quantitatively characterize the degree of fracture closure. Previously, we have adopted the critical closure pressure as the characterize parameter of mudstone fracture closure, now we will use the displacement pressure as the characterize parameter to analyze the closure of mudstone fracture.

When the researchers studying the topic of the mudstone as a sealing caprock, taking into account, considering the mudstone formed into fault under the stress fracture, the fault has two aspects of function: (1) as a migration pathway of oil and gas that makes the oil and gas which are sealed by mudstone migrating along the sealing of along the fault; (2) Impermeable fault is used as a closed boundary to stop the oil and gas from migrating. The first part is we need to study under how much pressure could the fluid in the mudstone fault flow. The researchers call the pressure when fluid broke the mudstone closure and started flow as breakthrough pressure.

Breakthrough pressure has something to do with the mudstone thickness, flow and the required time for a flow of fluid as well as other factors. For the convenience of comparison, the researchers proposed formula Xiao Bo, which is only related with the breakthrough time under flow pressure in two points, and finally we get the quantitative parameter called displacement pressure: the formula is:（formula 1)

$$p = \frac{\Delta p_1 t_1 - \Delta p_2 t_2}{t_1 - t_2} \qquad (1)$$

In the formula： p -- displacement pressure, MPa;

Δp_1、Δp_2 -- breakthrough pressure (flow pressure), MPa;

t_1、t_2 -- breakthrough time under corresponding pressure, s.

Static geology study using the displacement pressure as quantitative parameter to analysis the opening and sealing of the fault in the mudstone, displacement pressure requires only one value, if exceeding this value, the fluid in the cracks could flow and fault opens; on the contrary, the mudstone fault closes. This research

applied the displacement pressure to analyze the problems of the closure of mudstone fracture, the aim is to solve dynamic production demand, determining during production process the crack closure when flow pressure decreased to a certain value, needing to acquire the displacement pressure value under different flow pressure conditions, in order to compare. This is one of the difference between my research and static geology study. In addition, we have previously established the quantitative relationship between closure and the permeability, in order to make full use of the experimental results to have an in-depth study, this study also have measured displacement pressure under different closure to find out the regularity.

II. EXPERIMENTAL PROCEDURE

(1) Preparation for core samples;

(2) Artificial joint;

(3) Using aviation kerosene to saturate in high pressure vessels for 72 hours;

(4) Maintaining the injection pressure (flow pressure), measuring the breakthrough time under different confining pressure;

(5) Maintaining the confining pressure steady, measuring the breakthrough time in different injection pressure (flow pressure);

(6) Repeat step (3) ~ (5);

(7) Put the experimental data from (5) into formula (1) to calculate the displacement pressure. under different confining pressure.

III. THE RESULT OF THE EXPERIMENT

(1) Setting the pressure injection to apply different confining pressure on the mudstone samples, measuring the breakthrough time of nitrogen under different confining pressure, recording the data and drawing into a scatter diagram (fig.2).

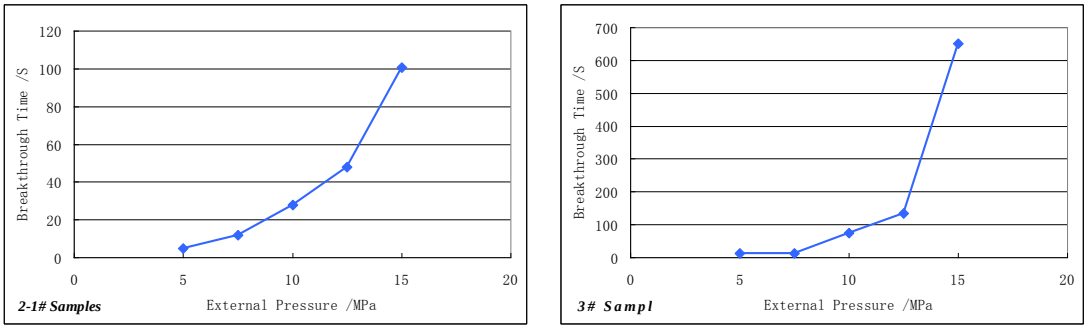

Fig.2 The breakthrough time of mudstone samples under different external pressure

（2）We put one mudstone sample into the core clamping device, applying a constant external pressure, respectively change the differential pressure for two times, recording every breakthrough time of objecting pressure and substitute it into formula, getting the displacement pressure under this external pressure. Then change the external pressure, and repeat the experiments which leads us to the next external pressure of displacement pressure value (Fig.3).

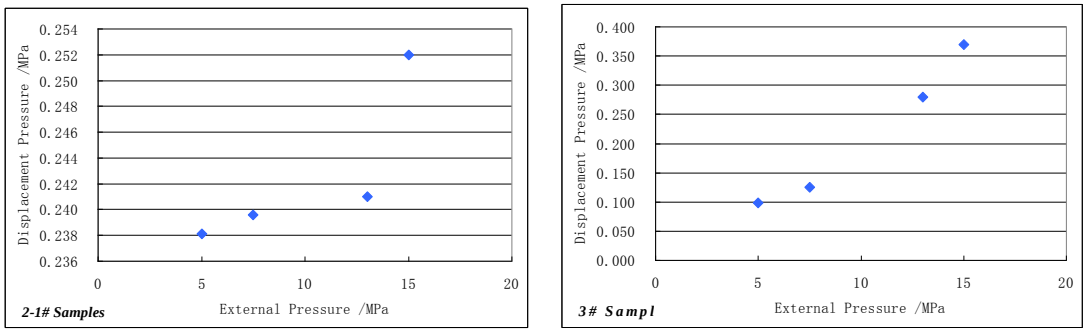

Fig.3 The displacement pressure of mudstone samples under different external pressure

(3) As mentioned before, external pressure and internal pressure have different effect in the changing degree of permeability, we put the change of the permeability of internal pressure, the change of the permeability of external pressure, and the change of the displacement pressure of external pressure from mudstone core samples drawn all in a map (fig.4) to analysis its changing rule.

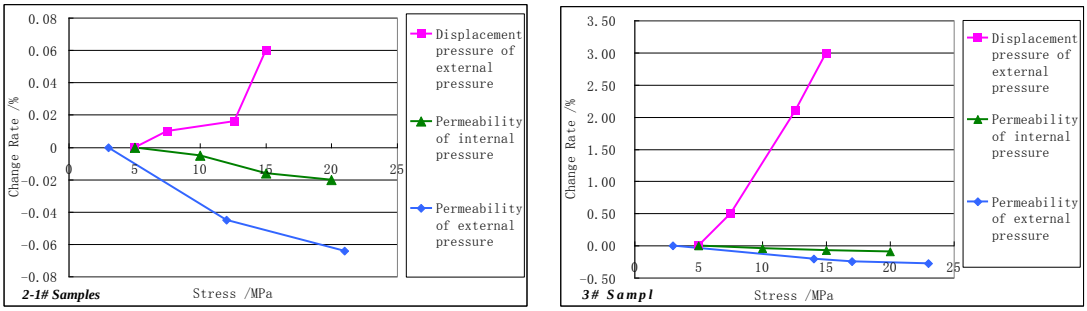

Fig.4 The changing trend of permeability and displacement pressure under different stress

IV. THE RESULT ANALYSIS

(1) With the increase of the external pressure, the pore crack of rock is compressed, the permeability decreases, and the same flow rate of fluid in the same pressure needs longer time;

(2) Under different external pressure conditions, the fluid displacement pressure of mudstone is different, with the increase of external pressure, it also shows that the depth of the mudstone reservoir fluid discharge pressure difference is greater;

(3) Under different stress, the permeability of the external pressure and the production pressure difference decreases with the increase of the numerical value, the displacement pressure of the external pressure increases with the increase of the stress, and the degree of increase is greater than the former two.

V. CONCLUSION

In this study, we take the core samples obtained from Gu Ping No.1 well as the sample, and have theoretical and experimental studies on the closure pressure of the mudstone fracture are carried out, conclusions are drawn as follows:

(1) Applying the uniaxial stress into core samples to test their stress-strain characteristics. According to the stress strain curve, the mudstone belongs to the plastic - elastomer kind and it's more likely to have plastic deformation and it's difficult in recovering after the deformation under a certain loading stress.

(2) Applying the method of displacement pressure to a quantitative laboratory study on the closure pressure of mudstone fracture. We change the flow pressure and confining pressure to study the mudstone fracture closure

pressure under different kinds of stress change. The smaller underground permeability have a great influence on the displacement pressure, as for the actual production pressure difference change leads to a relatively small change in permeability, we need to have a greater degree of production pressure difference increase so as to keep the stability of flow;

(3) This study is established on the theory and the basis of experimental data analysis, due to the limitation of objective conditions, we can not fully simulate a real underground environment. The conclusion has a guiding significance, even it can't totally match the actual situation of underground;

(4) If the fracture of underground mudstone closure, it may under a comprehensive influence of various factors such as the stress change and water sensitivity and the force change is merely one of the main factors, if we need to obtain a comprehensive and complete solution, the comprehensive analyze every factor is still needed.

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