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Study on Fault Lateral Sealing Based on SGR Method

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Abstract

Bozhong A Oilfield is located in the northeast of Huanghekou Sag in the Bohai Bay Basin, and is a complex fault block oilfield. The main oil bearing horizon is the lower Minghuazhen Member, belonging to shallow water delta sedimentation. For the rolling exploration and evaluation of adjacent fault blocks, this paper uses the mudstone smear method to analyze and accurately characterize the lithological contact relationship between the two walls of the fault. Based on the establishment of different reservoir docking modes on the two walls of the fault, the sealing parameters are calculated to evaluate the sealing ability of the fault, thereby evaluating its reservoir formation characteristics, and predicting the height of the oil column. The above methods provide geological basis for further rolling expansion and potential tapping in the study area and surrounding areas, and have guiding significance for exploration and rolling potential tapping in similar blocks in the Bohai Sea.

Keywords

Fault Block Reservoir, Shale Smear, Oil Column Height, Fault Pressure

1. Introduction

Bozhong A oilfield is a complex fault block oilfield. Due to the small scale of single sand body reserves and many undeveloped fault blocks, there is potential for the oilfield. At the same time, due to the complexity of reservoir formation in the lower Minghuazhen Formation, during the rolling potential tapping process, the oil column height in some fault blocks is relatively low, even without reservoir formation. The sealing ability of faults is the main research direction of rolling potential tapping in similar oilfields, so whether the sand bodies of the oilfield form reservoirs are closely related to the sealing of faults [1] [2] [3]. Quantitative prediction of oil column height in unknown fault blocks is the key to efficient rolling. Through statistical analysis of drilled wells, fault sealing accounts for 62% of the reasons for the failure of rolling evaluation within the oilfield. Therefore, it is necessary to carry out research on fault sealing, and then establish a quantitative relationship between fault sealing and oil column height [4]. This article attempts to use development well data to finely dissect the lithological spatial combination relationship of fault planes, calculate the fault rock evaluation parameter SGR, and validate the fault sealing evaluation method based on geological research results, which has guiding significance for similar oil fields [5].

2. Geological Setting

Bozhong A oilfield is a complex fault block oilfield developed in the Huanghekou depression in the Bohai Bay area. Constrained by multiple factors such as structure, fault, and lithology, Bozhong A Oilfield is located in the Huanghekou oil generating depression, and is one of the most favorable areas for oil and gas enrichment in the Bohai Sea. The main types of oil and gas reservoirs include lithologic, structural-lithological, and structural oil and gas reservoirs. The main oil bearing formation of the oilfield is the Minghuazhen Formation, dominated by shallow water delta deposits. The porosity distribution range of the reservoir is 8.6% - 41.9%, with an average of 31.2%. The permeability distribution range is 5 - 4915 mD, with an average of 712 mD. The reservoir physical properties are characterized by high porosity and permeability.

3. Quantitative Evaluation of Lateral Sealing of Faults

3.1. Mechanism and Type of Lateral Fault Sealing

For mudstone smear research methods, how to characterize the characteristics of fault rocks in fault zones is the key to evaluating the sealing performance [6]. The main control factor of fault rock is the shale content of the fault zone, and the lateral sealing attribute value of the fault zone can be used to simulate the content of fine grained material in the fault zone [7]. The commonly used lateral sealing attribute values include CSP, SSF, and SGR, among which CSP (Bouvier, 1989) is suitable for using plastic mudstone in shear environments; SSF (Lindsay, 1993) is suitable for shale in compression environments; SGR (Yielding, 1997) is an algorithm that comprehensively considers various geological factors. Field measurements and experimental calculations indicate that the SGR value in the fault zone has a good correlation with the fine grained material in the fault zone, that is, the larger the SGR value, the more fine grained material in the fault zone, and the stronger the lateral sealing ability of the fault [8]. The shale smear factor (SSF) is a parameter characterizing the continuity of the mudstone smear layer. If SSF is less than 4, the mudstone smear can maintain spatial continuity. In this paper, SGR method is mainly used to simulate the composition of fine particles in fault zones and quantitatively characterize the lateral sealing of faults.

Due to the difference in permeability between the fault zone and surrounding rock, it is the main reason why the fault is sealed (**Figure 1**). That is, there is a large displacement pressure difference between the fault zone and the surrounding rock.

In the theoretical model, the rising and falling walls of a fault are in contact with each other in a plane. If the reservoirs on both sides of the fault are connected, the fault is open, and if the reservoirs are connected to the mudstone layer, the fault is closed. However, in reality, the rocks on both sides of the fault rupture, forming a fault zone. The sealing ability of a fault is affected by the lithology of the fault zone. This paper quantitatively evaluates the sealing ability of the fault by characterizing the rock characteristics of the fault zone's fault layers.

3.2. SGR Evaluation of Lateral Sealing Principle of Faults

In this paper, it is necessary to quantitatively characterize the characteristics of fault rock in the reservoir junction area in the fault zone to evaluate whether it is sealed. The research mainly uses SGR method to simulate the composition of fine particles in the fault zone and study the lateral sealing ability of the fault.

Formula (1) can be determined from the pattern diagram in **Figure 2**:

$$\text{SGR} = \sum \left(Vsh \cdot \Delta Z \right) / D \times 100\% \tag{1}$$

ΔZ indicates the thickness of the stratigraphic zone (m), Vsh represents the shale percentage content of the formation zone (%), D denotes the fault offset of a fault (m).

The difference in in-situ pressure measured on the rising and falling walls of a fault at the same depth on the fault plane is called the across fault pressure difference, or AFPD for short. When there is water in the fault zone, the aquifers passing through the fault zone have the same pressure (**Figure 3**).

3.3. Quantitative Characterization of Fluid Height in Fault Block Sealing

The research data shows that there is a positive correlation between the shale

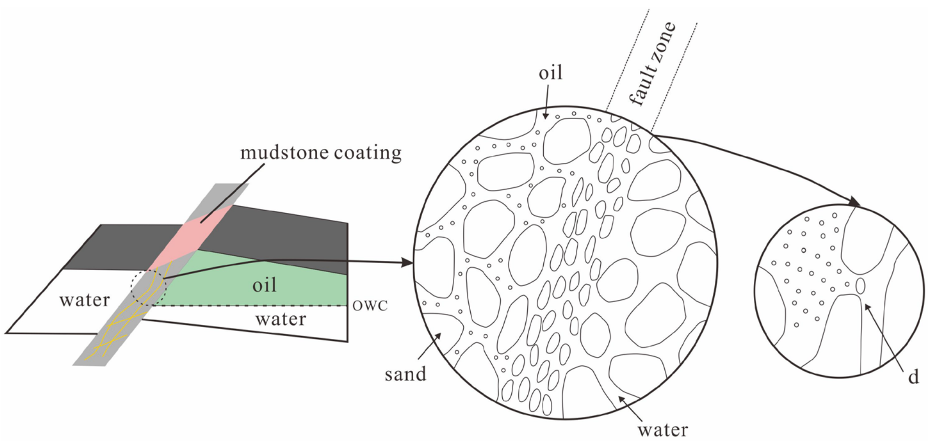

Figure 1. Mechanism model of fault zone sealing for oil and gas.

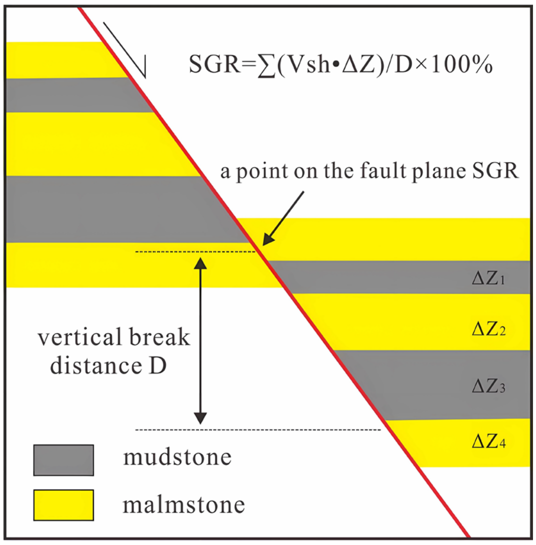

Figure 2. Calculation model of fault lateral sealing attribute value.

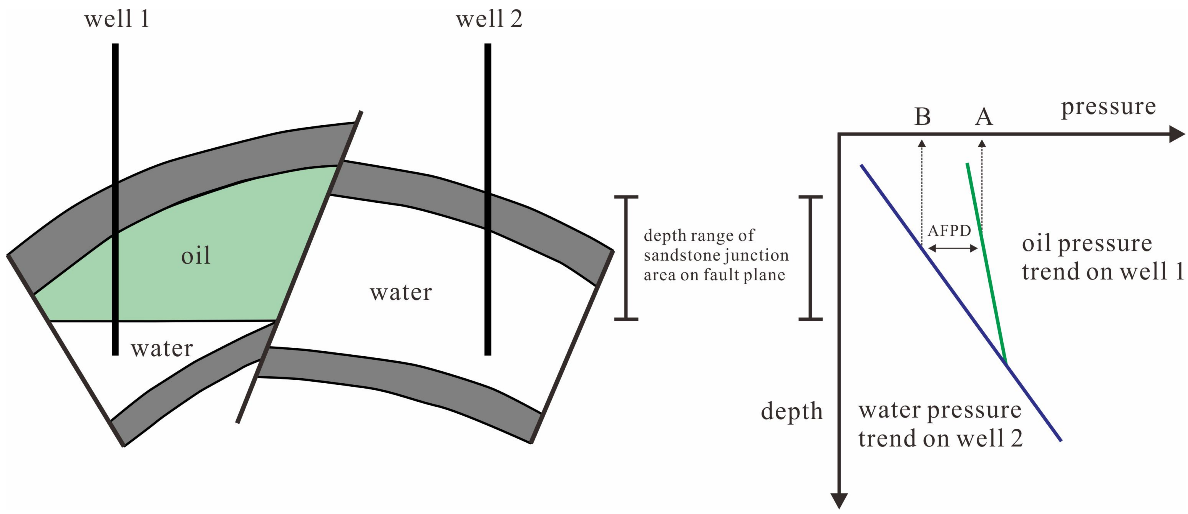

Figure 3. Schematic diagram of AFPD. (a) The fluid on both sides of the fault is different; (b) Pressure depth curve of wells on both sides of the fault.

content (SGR) of the fault zone and the fault sealing pressure difference (AFPD, it is the differential pressure across the fault). The sealing ability of fault rocks can be calibrated using statistical methods. The relationship between the SGR of the control zone fault and the pressure difference (AFPD, it is the differential pressure across the fault) on both sides of the corresponding original oil reservoir fault can be analyzed, and a quantitative expression of SGR-AFPD is established as the basis for quantitative evaluation of the fault sealing ability (**Figure 4**).

$$H = \frac{\text{AFPD}}{(\rho_w - \rho_o)g}\rho = \frac{0.0683 \cdot \text{SGR} - 1.3562}{(\rho_w - \rho_o)g} \quad (2)$$

AFPD is the differential pressure across the fault (MPa). H is the height of the

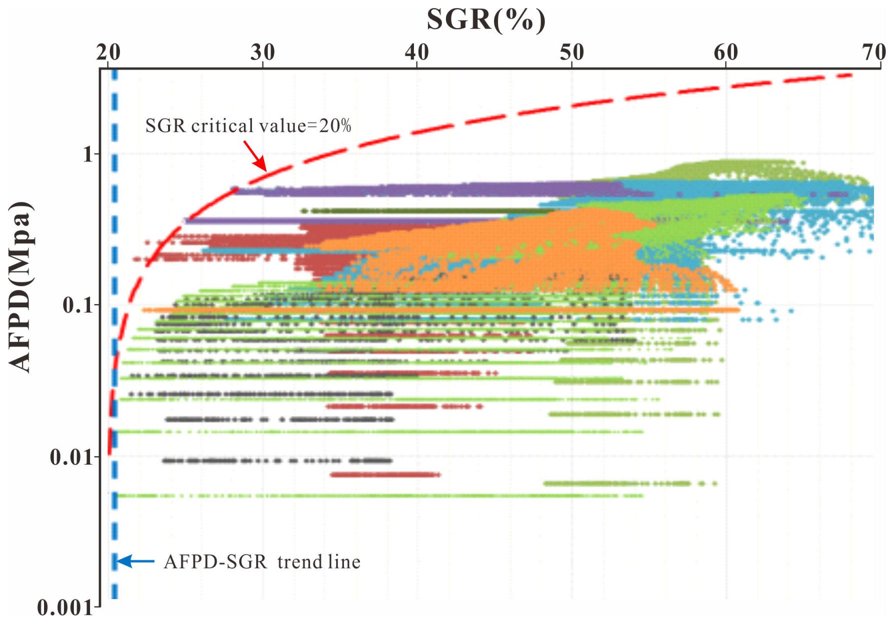

Figure 4. Quantitative characterization diagram of fault sealing capacity (AFP and SGR Matching Chart).

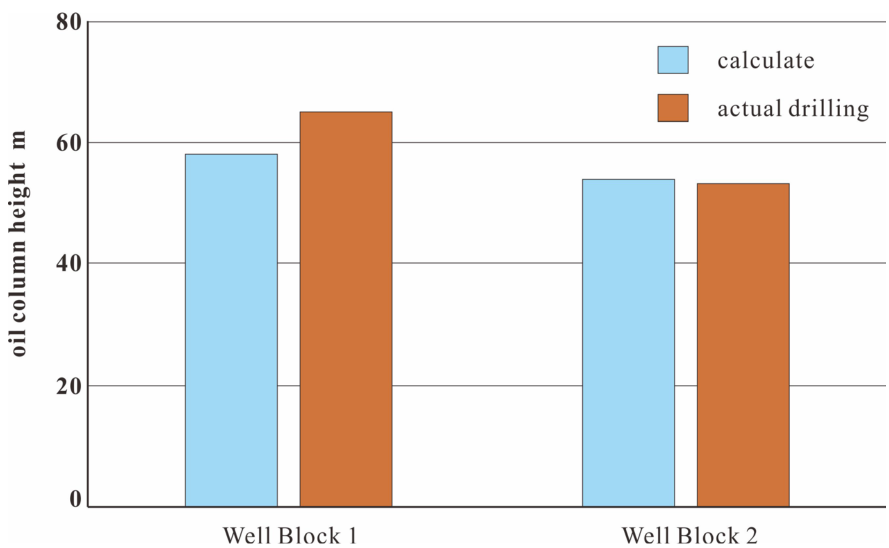

Figure 5. Comparison of actual drilling for prediction of oil column height in north block of oilfield A.

hydrocarbon column (m). SGR is the percentage of mud contained in the fault zone (%). ρ_w is the density of formation water in the reservoir (kg/m^3). ρ_o is the density of oil in the reservoir (kg/m^3).

Through analysis, it is believed that the oil column height in the north block of Well Block 2 in Bozhong A Oilfield is above 50 m. From the detailed reservoir description results, it can also be seen that the reservoirs in this area are developed. Therefore, the goal of rolling evaluation around the oilfield is targeted at this area. Through rolling edge expansion evaluation, it is determined as an oil layer, and the prediction of oil layer thickness is relatively accurate (**Figure 5**).

4. Conclusion

Through research on the correlation between the shale content (SGR) of fault zones and the fault sealing pressure differential (AFPD), fault sealing research is carried out, sealing parameters are calculated, and sealing performance is quantitatively evaluated. This more rapid and precise evaluation method than in the exploration stage meets the basic needs of the development stage. In complex fault block oilfields, the study of fault sealing can predict the oil column height in non drilled well areas and find potential areas for edge expansion. This technical study provides geological basis and risk assessment for rolling development around complex fault block oilfields.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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