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Numerical Modeling Method Considering Fault Conductivity

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Abstract:

Fault can serve as an important channel for hydrocarbon migration and fluid migration, and takes part in sealing oil and gas accumulation. Fault opening has serious pollution to groundwater environment. In most cases, the transition state between fault being completely closed or completely opened, but there is a difference in the sealing ability of its. In reservoir simulation, traditional fault spatial description tool, which leads us to analyze the closure and stability of the faults only as a two-dimensional plane. Then in order to more accurately predict the fluid migration and the stability of fault zones and realize the fault 3D quantitative simulation, we need to new method of fault description to describe and characterize the fault structure more accurately and deformation quantitatively. Based on the traditional modeling technology, we will explicitly consider the method of quantitative evaluation of fault sealing ability in the internal structure of faults. The method can show 3D feature of the fracture zone and the fault will be considered as a deformed rock mass rather than a surface like the anisotropy of permeability and the curvature of fluid channel are clearly represent in the reservoir model. On the scale of simulated grids, the flow and uncertainty between grids on both sides of the fault zone are prior rather than using historical fitting posteriori. And the modeling technology can clearly characterize fault sealing ability and contribute to correctly understand ad predict oil and gas migration, focus, loss process and oil and gas distribution rule.

Keywords: *Numerical modeling method, Fault conductivity, Fault sealing, Internal structure of faults.*

I. INTRODUCTION

Traditional description tools of fault space, which cause us to analyze the fault sealing and its stability is still simply to be considered as a two-dimensional plane. We need a new description of the fault for a more accurate description on the structure and deformation characteristics of the fault and the quantification of the closure property, in order to predict the fluid migration in fault zone and the stability of the fault zone more accurately and realization of 3D quantitative simulation of fault [1-3]. The studies explicitly consider the Quantitative evaluation of fault sealing method which based on the study of fault sealing mechanism. The introduction of the fault model makes fault understanding for rock deformation rather than a surface structure and the physical characteristics of rocks is related to many factors, 3D features of fracture zone such as permeability anisotropy, capillary effect, and the curvature of fluid channel can be characterized in the reservoir model clearly by fault phase method. The scale of the simulation, flow and uncertainty between the two sides of the fault zone are priori instead of using history to fit numerical modeling [4]. The characteristic of the fault zone can be characterized as a phase and make how to describe the fault phase clearly in oil field, meanwhile the fault model of complex influence factors can be embedded into the large scale oil field model by this modeling technique and it contribute to the correct understanding and prediction of oil and gas migration, accumulation, dissipation process and the distribution of oil and gas [5,6].

The Bozhong M oilfield is selected as the research block and according to the fault interpretation results and micro structure understanding, and based on the original geological model, we establish the geological model of the M oilfield. Then on the basic of the fault sealing and injection production relation, the historical fitting of the dynamic production index of single well and whole area is carried out, and the distribute law of the remaining oil fields is analyzed.

II. THE ESTABLISHMENT OF GEOLOGICAL MODEL OF M BLOCK

2.1 Fault Model

The software used of the establishment of geological model is the PETREL of Schlumberger corp, which carries out the corresponding treatment and analysis and eliminate the abnormal values, and the PETREL modeling data flow is formed and introduced into the software. According to the achievement of the fault interpretation, a new fault model is built by adding 6 new subseismic faults.

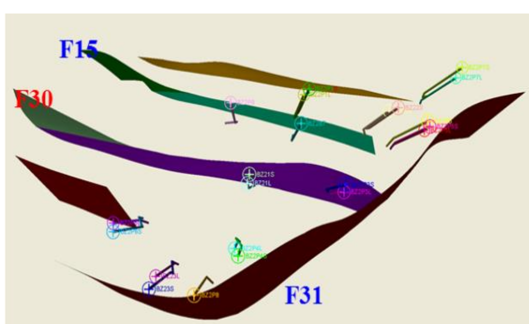

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Fig 1: Modified fault model

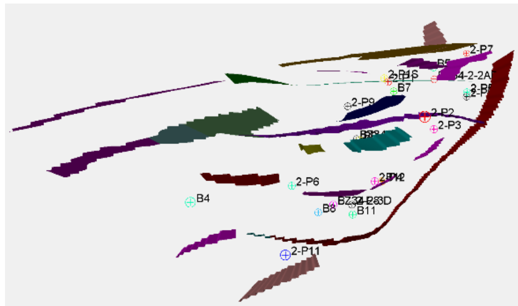

Fig 2: Original fault mode

2.2 The Establishment of Structural Model

Structural modeling is the most basic and important work in geological modeling. It establishes a three-dimensional grid which accords with the geological and structural features of the work area for subsequent sedimentary microfacies modeling and attribute modeling.

On the basic of micro structural interpretation, a structural model is established. And according to the actual situation of the work area and the density of the well pattern, the plane step length of a single grid is finally chosen.

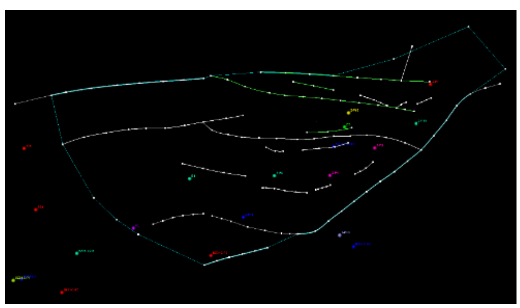

Fig 3: Boundary figure of geological model of target block

After finished the three-dimensional grid, it can directly use the stratified data of the well to establish the level model of the work area and use interlayer thickness graph to establish the stratigraphic model.

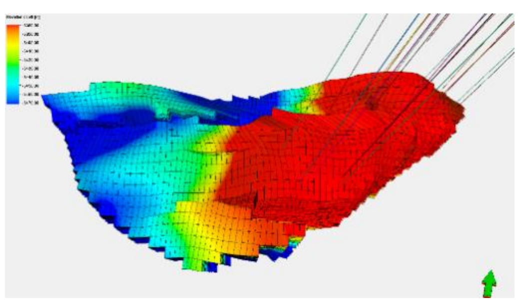

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Fig 4: Three bit grid structure model

It can be seen from the structural model that the overall structural plane of the work area varies greatly, showing a slight inclination from the south to the East, but with little structural dip and many faults.

2.3 The Establishment of Attribute Model

A phase model is used to constrain the permeability and effective thickness of the model, and algorithm used is the sequential Gauss model, and through the attribute modeling of the next module, the permeability porosity and static wool ratio attribute models are obtained.

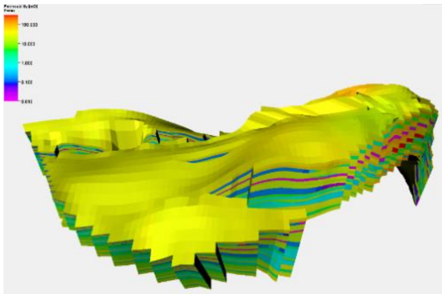

Fig 5: Three dimensional porosity model of industrial area

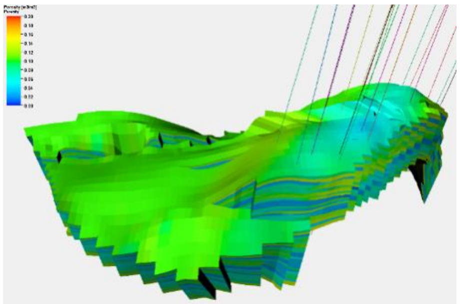

Fig 6: Three-dimensional permeability model of industrial area

III. THE STUDY OF CONSIDERING FAULT SEALING

In Eclipse, the fault is mainly simplified to two planes, and the fault closure is mainly caused by grid conductivity factor.

The calculation method of corner grid conductivity in Eclipse is:

$$\mathrm{tranx} = \frac{C_{darcy} \cdot TMLTX}{\frac{1}{T_i} + \frac{1}{T_j}}$$

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(among)

$$D_i = D_x^2 + D_y^2 + D_z^2$$

$$T_i = k_x \times ntg_i \times \frac{A.}{D_i.D_i}$$

TMLTX: Conductivity coefficient;

Kx: X-permeability

Cdarcy: Darcy constant, the lower value of the metric unit in the E100 model is 0.008527.

According to the tranX formula of conductivity, conductivity is related to permeability, and in order to facilitate date processing, we directly used the conductivity coefficient to characterize the sealing ability of the broken surface.

Fault conductivity:

$LogK_f = 4SGR - 1/4 \times \log(D)(1 - SGR)^5$ SGR: mud smear rate, %; D: fault break distance, m.

The conductivity coefficient can be simplified to the ratio of the parent rock to fault rock permeability, that is:

$$TMLTX = \frac{k_f}{k_x}$$

Using the above formula, a fault conductivity model is established.

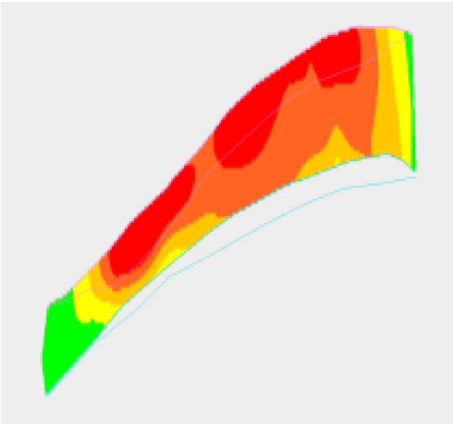

Fig 7: Fault SGR attribute model

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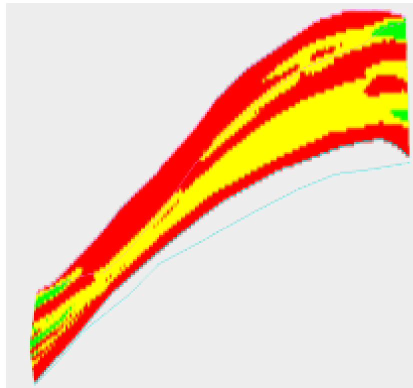

Fig 8: Fault thickness attribute model

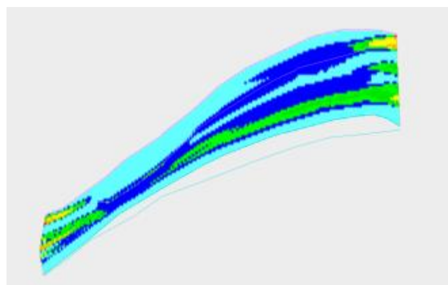

Fig 9: Fault permeability attribute model

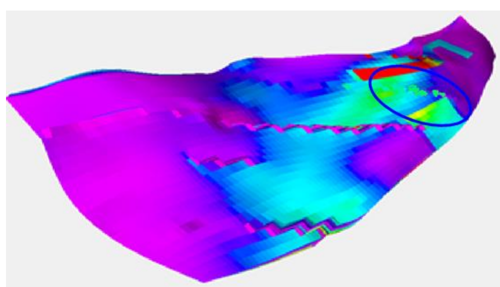

Fig 10: Fault conductivity model

IV. HISTORICAL FITTING

Compared to the traditional method, in the scale of the simulated grid, the flow and uncertainty between grids on both sides of the fault zone are prior rather than after using the historical fitting posteriori. The modified numerical simulation model can directly increase the fitting rate by 20% without the need of a posteriori parameter fitting adjustment process.

The historical fitting begins on August 1990 and the ends is December 2014. The oil and gas production is used to restrict the oil. The extraction degree of north central block is 23,24%

and its comprehensive water content reached 73.35%, actual cumulative oil production is 301.37×104m^3, accumulative cumulative oil production is 299.94×104m^3, fitting error is 0.48%, the fitting rate of the dynamic index in the whole region is above 95%.

Fig 11: Historical fitting curve of liquid production

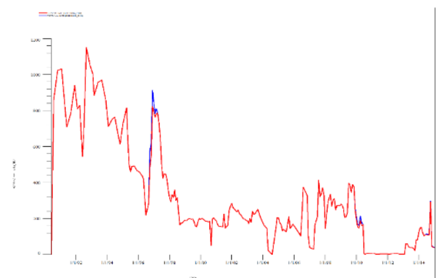

Fig 12: Historical fitting curve of oil production

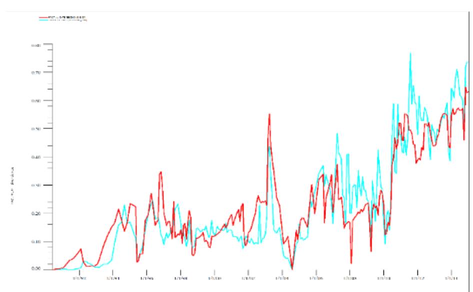

Fig 13: Historical fitting curve of water cut

V. ANALYSIS OF FLUID UNDER THE CONTROL OF FAULT

In the cases of complete closure of the fault, like figure 5, fluid does not flow through the fault. But in reality, the water injection in p3 well, water in p1 well on the north side of the fault, it can be proved that the fault is a semi closed fault. And the modified fault streamline is shown in figure 6 which is consistent with the actual injection production relationship.

According to the prediction results, it is found that the water flooding level near the main

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line is high as figure 7, and most of the water flooding fronts have already reached the production well, under the occlusion of the fault. The location of the sealing position near the fault is poor, the oil situation is high, the remaining oil is enriched, and the remaining oil in the opening position is displaced to a certain extent.

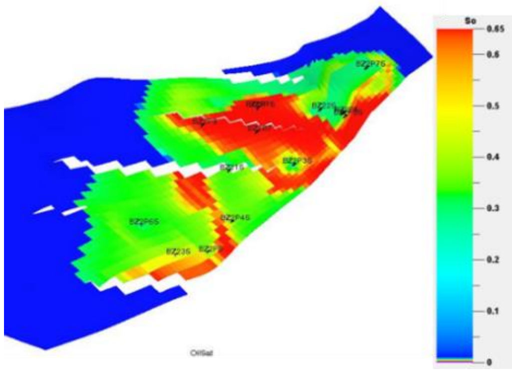

Fig 14: Top residual oil saturation diagram

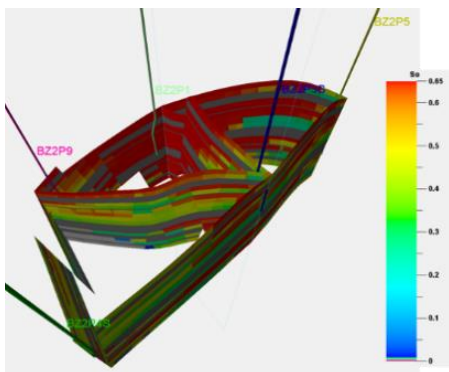

Fig 15: Residual oil saturation palisade

VI. CONCLUSION

The numerical simulation of fault sealing shows that the residual oil near the fault cane displaced to different degrees for the semi closed fault. The simulation method is more practical, and the fault is blocked by the fault, the fault closed position is injected, the effect is poor, the oil saturation is higher, and the remaining oil is enriched.

For polymer flooding reservoirs, for polymer flooding reservoirs, when the pressure increases near the fault, the fault is easier to open. Fault opening not only affects oil and gas migration, but also causes serious pollution to underground environment. For offshore oilfields, fault sealing monitoring is difficult in development engineering, and oil and gas leakage is more likely to occur.

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