# Evaluation of integrated geological engineering reservoir reconstruction in Block X of Bozi

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**Abstract:** The geological structure of the reservoir in Bozi-Dabei area is complex, and the longitudinal difference of rock mechanical properties of the reservoir is large. Most of the current evaluation techniques after reservoir reconstruction are based on the fitting of construction pressure based on the logging curve of a single well, so as to analyze the fracture morphology and the geometric dimensions of length, width and height after pressure. It is difficult to explain the fracture morphology and geometric parameters correctly because the interpretation methods used do not comprehensively consider the influence of natural fractures, 3D geological properties and 3D geomechanical properties. In order to explain the artificial fracture morphology more accurately, the target layer ant body is generated by using 3D original seismic data, and the natural fracture model of three different reservoir types in Bozi X block is generated, which provides geological basis for the integrated demonstration. By combining dynamic and static data and multidisciplinary methods, a one-dimensional rock mechanics profile model is established, and a three-dimensional geomechanical model of three different reservoir types in Block X of Bozi is established by combining geological model and deep diagenesis theory. The matching relationship between horizontal stress, fault strike and natural tensile fracture distribution is comprehensively analyzed and evaluated, providing a geomechanical basis for the evaluation of integrated reservoir reconstruction. Integrated geological model and geomechanical model are closely combined with engineering parameters to establish an integrated true three-dimensional artificial fracture model. On this basis, the optimization research and design of the parameters of displacement, liquid volume and sand ratio are completed. The optimal flow rate of Class I reservoir 6-7 ($m^3 \cdot min^{-1}$), Class II reservoir 5-6 ($m^3 \cdot min^{-1}$), Class III reservoir 4-5 ($m^3 \cdot min^{-1}$), Class I reservoir 600-700 $m^3$, Class II reservoir 600-700 $m^3$, Class III reservoir 500-600 $m^3$, Sand ratio of 15%-20% for Class I reservoir, 15%-20% for class II reservoir and 20%-25% for class III reservoir are the optimal construction parameters, which provide guidance for field construction.

**Keywords:** Bozi Block; Tight reservoir; Geological engineering integration; Ant tracking; Fracturing parameter optimization

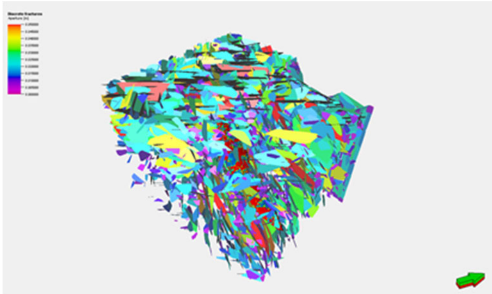
## 1. Introduction

The reservoirs in the Bozi-Dabei area are the second and third lithologic sections of the Cretaceous Bashijiqike Formation, and this set of reservoirs is widely distributed regionally, with the second lithologic section being a subphase of the braided delta front and the third lithologic section being a subphase of the fan delta front. The Lower Cretaceous of Bozi-Dabei area is a fractured dense sandstone reservoir formed under the depositional system of fan delta and braided river delta, and the area is dominated by feldspar lithic sandstone, followed by lithic feldspar sandstone, and the particle-size is dominated by medium and fine grains; the reservoir space is dominated by intergranular pores (primary intergranular pores, intergranular dissolution expanded pores) and dissolved pores in grains, with a very small number of micropores and fissure pores; the reservoir fractures is well developed, and the main ones are upright and high-angle shear fractures. The geological structure of the area is complex, the mechanical properties of reservoir rocks vary greatly in the longitudinal direction, and the local stress disturbance characteristics are obvious because of the existence of a large number of upright and high-angle shear fractures in the plane. Most of the current techniques for post reservoir reforming assessment are based on fracturing construction curves for G function, horner function and other characteristic curve analysis, or construction pressure fitting based on single-well logging curves to analyze the post-pressure fracture morphology and geometric dimensions of length, width, and height. And the interpretation methods used basically do not consider the effects of natural fractures, 3D geological attributes and 3D geomechanical attributes, and do not consider the single fracture model of fractured dense sandstone reservoir modification of multi-fracture multi-stage stress perturbation characteristics, which makes it difficult to correctly interpret the morphology of post-pressure fracture and geometric parameters.

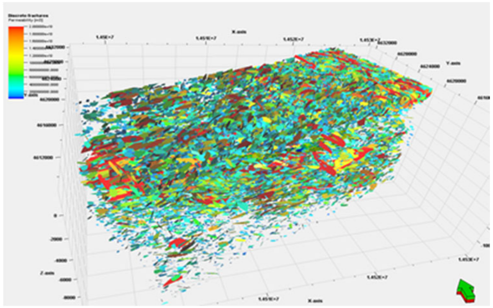
In recent years, the existing design of fracturing parameters is mainly based on numerical simulation of single wells and analytical methods. Gou et al used numerical simulation to optimize the fracturing parameters based on a fine geological model of the reservoir. Qu et al established the gas reservoir model and fracture model, and optimized the ground fracturing parameters. Zhong used an analytical method to optimize the fracturing parameters based on basic seepage theories such as reset potential and potential superposition principle. Therefore, this paper establishes a block geomechanical model based on the regional stress changes and deep diagenesis characteristics, while considering the dynamic ground stress field changes coupled with faults, natural fractures and dynamic changes in production. Based on this, an integrated artificial fracture model containing geological model and geomechanical model is constructed for the evaluation of post-pressure artificial fracture morphology and geometry, and the longitudinal and planar expansion law of artificial fracture in typical well areas has been studied to comprehensively complete the optimization study of fracturing for reservoir modification and provide theoretical basis for the preference of regional fracturing construction process and optimal design of parameters.

## 2. Modeling of natural fractures in the target layer

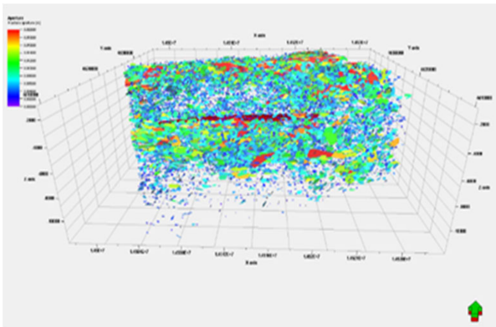
Using the 3D original seismic data body to generate the target layer ant body. First of all, through the original seismic data body construction smoothing processing, to reduce the noise interference, and enhance the continuity of the seismic reflection wave in the same phase axis. Then the ANOVA technique is used to obtain the variance body for the seismic data body that has been processed by tectonic smoothing to highlight the discontinuous information of the seismic data. Finally, the ant tracking parameters are tested several times to determine the optimal parameter values suitable for the study area, and the discontinuous traces in the ant tracking technology that satisfy the preset fracture conditions in the other differential body are tracked to generate the natural fracture model of the ant body of the three different reservoir types in Block X of Bozi, as shown in Fig. 1.



(a) Type I reservoir



(b) Type II reservoir



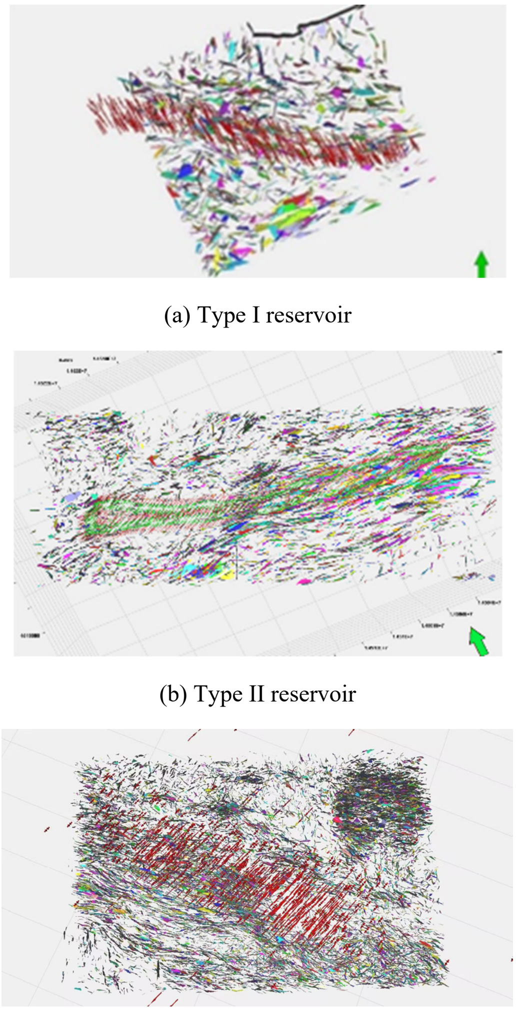
(c) Type III reservoir

Fig. 1 Natural fracture model of ant body in 3 different reservoir types in Block X of Bozi (a, b, c)

## 3. Mechanical environment construction and stress-strain matching calibration of deep-seated stratum

The initialized 3D geomechanical attribute body is created by filling in the overlying strata, basement rocks and surrounding rocks on the basis of the geological model. Horizontal stress is applied around the area to simulate the process of deep-seated stratum formation, fit the results of mechanical interpretation of well points, correct the basic parameters of geomechanics, and preliminarily obtain a static three-dimensional geomechanical model under the present-day ground stress conditions. Load the stress environment, faults and natural fracture network system, simulate the deep rock formation process, respectively establish the artificial fracture-containing deformable saturated reservoir flow-solid coupling seepage model, artificial fracture-containing deformable saturated reservoir flow-solid coupling elastic deformation of rock model, artificial fracture-containing deformable saturated reservoir coupling temperature field model, synthesize the initial 3D geostress model, the results of the numerical simulation of reservoirs derived from the 3D pore pressure and temperature field, and comprehensively establish the dynamic geostress model. temperature field derived from the numerical simulation results of the reservoir, and establish the dynamic geostress model.

Based on fault strike of the block, the horizontal stress direction is analyzed, and the initial stress direction of the model is preliminarily generated by combining with the regional stress study. Among them, positive faults and tensional fractures have a certain matching relationship with the direction of the maximum horizontal principal stress based on their historical causes, especially the direction of the tensional natural fractures formed within each period is basically consistent with the direction of the maximum horizontal stress of the current period. On this basis, the dynamic geomechanical model is formed by fitting and adjusting the rock mechanical parameters through multiple stress evolutions, and finally reaching the maximum unbalanced force convergence.



(a) Type I reservoir

(b) Type II reservoir

(c) Type III reservoir

Fig. 2 Faults, natural fractures and maximum horizontal direction matches in 3 different types of reservoirs in Block X of Bozi

## 4. Evaluation and optimization study of artificial fractures after fracturing

The expansion law of artificial fracture is not only related to geological conditions, but also linked to the construction parameters in the field. In order to optimize the best construction parameters with a view to achieving the best fracturing effect, based on the established natural fracture model and 3D geomechanical model, a true 3D artificial fracture model of Pre-Tertiary stratum in well A is established, and the optimization study of its fracturing construction parameters is carried out by using Single Factor Method (as shown in Table 1). It is necessary to study the artificial fracture expansion law of different reservoir types in Bozi block and finally get the optimized fracturing design parameters.

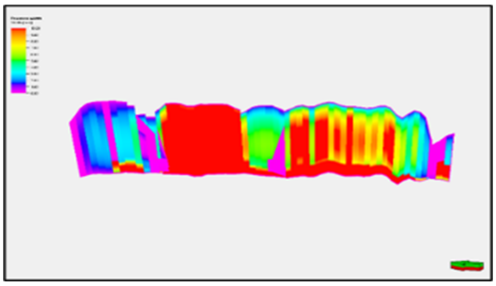
Table 1 Simulation range of artificial fractures parameters

| **engineering parameters** | **range** | | |
|---|---|---|---|
| | **Type I reservoir** | **Type II reservoir** | **Type III reservoir** |
| displacement of fracturing fluid/ $m^3$/min | 3、4、5、6、7、8 | 2、3、4、5、6、7 | 2、3、4、5、6、7 |
| volume of fracturing fluid/ $m^3$ | 300、400、500、600、700、800 | | |
| sand proportion/% | 5、10、15、20、25、30 | | |
| Proportion of prepad fluid/% | 20、30、40、50、60、70 | | |
| perforation thickness/m | 2、5、8、11、14、17、20 | | |

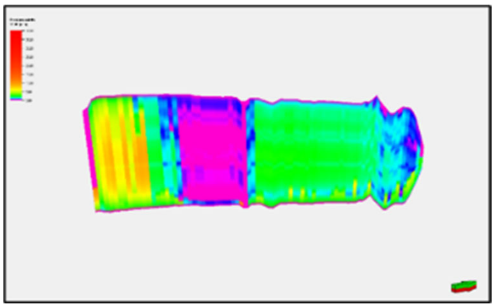
### 4.1 Displacement of fracturing fluid

Based on the established fracturing model to simulate the effect of displacement, the displacement was set to 2, 3, 4, 5, 6, 7 and 8 ($m^3$/min), respectively, to analyze and study the changes of fracture length, height, and width, as well as the changes of the support area and the transformation volume under different displacements. With the increase of displacement, the overall trend of fracture length, height, support area and transformation volume shows a rising trend, and the transformation effect of the artificial fracture network is reflected in the size of the values of the fracture length and support area, when the displacement reaches 6-7 ($m^3$/min) (Type I reservoir), 5-6 ($m^3$/min) (Type II reservoir), 4-5 ($m^3$/min) (Type III reservoir), the artificial fracture length, support area and transformation volume size tend to be stable, and the comprehensive site economic factors are considered, so the optimal displacement is considered to be 6-7 ($m^3$/min) for type I reservoir, 5-6 ($m^3$/min) for type II reservoir, and 4-5 ($m^3$/min) for type III reservoir. The artificial fracture morphology at optimal displacement for the 3 types of reservoirs are shown in Fig. 3.

(a) Type I reservoir



(b) Type II reservoir



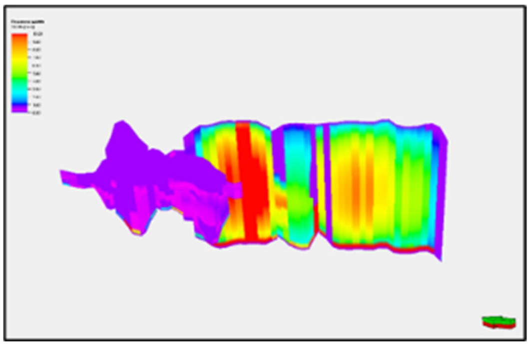
(c) Type III reservoir

Fig. 3 Artificial fracture morphology at optimal displacement for 3 types of reservoirs

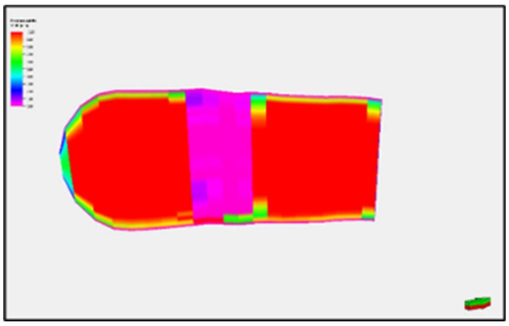
## 4.2 Volume of fracturing fluid

Based on the established fracturing model to simulate the influence of fluid volume, set up 6 groups of fluid volume data, respectively 300, 400, 500, 600, 700, 800 $m^3$, to analyze and study the fracture length, height, width, as well as support area and transformation volume under the influence of different fluid volumes. From the simulation results, it is found that the fracture length and height as well as the support area and transformation volume show an increasing trend with the increase of fluid volume, and the parameters begin to stabilize when the fluid volume reaches the ranges of 600-700 $m^3$ (Type I reservoir), 600-700 $m^3$ (Type II reservoir), and 500-600 $m^3$ (Type III reservoir). Therefore, 600-700 $m^3$ of type I reservoir, 600-700 $m^3$ of type II reservoir and 500-600 $m^3$ of type III reservoir are considered as the optimal fluid volume. The artificial fracture morphology under the optimal fluid volume values of the 3 types of reservoirs is shown in Fig. 4.

(a) Type I reservoir



(b) Type II reservoir



(c) Type III reservoir

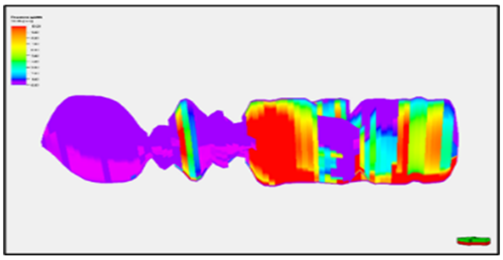
Fig. 4 Artificial fracture morphology at optimal fluid volume for 3 types of reservoirs

## 4.3 Sand proportion

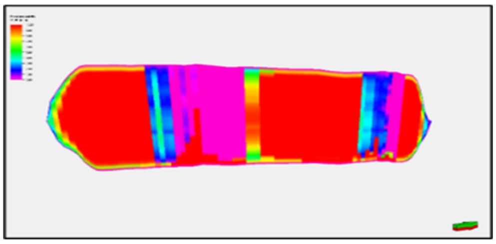
Based on the established fracturing model to simulate the effect of sand proportion, set the sand proportion as 5%, 10%, 15%, 20%, 25%, and 30%, and analyze the fracture length, height, and width, as well as the support area and thetransformation volume of the fracture with different sand proportion. From the analysis of the simulation results, it is concluded that the fracture width increases with the increase of sand proportion, and the fracture length, support area, and transformation volume first increase and then decrease with the increase of sand proportion, and then reach the peak value in the range of 15%-20% (Type I reservoir), 15%-20% (Type II reservoir), and 20%-25% (Type III reservoir), so that the optimal sand proportion values are considered to be 15%-20% for type I reservoir, 15%-20% for type II reservoir, and 20%-25% for type III reservoir. Therefore, it is considered that the optimal sand proportion is 15%-20%

for type I reservoir, 15%-20% for type II reservoir, and 20%-25% for type III reservoir. The artificial fracture patterns under the optimal sand proportion for the 3 types of reservoirs are shown in Fig. 5.

(a) Type I reservoir



(b) Type II reservoir



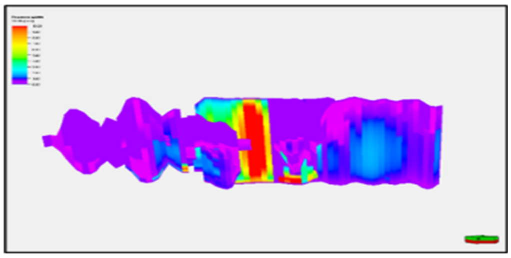
(c) Type III reservoir

Fig. 5 Artificial fracture morphology at optimal sand proportion for 3 types of reservoirs

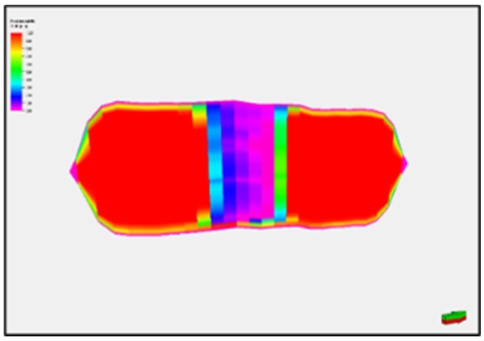
### 4.4 Proportion of prepad fluid

Based on the established fracturing model to simulate the effect of the proportion of prepad fluid, set the proportion of prepad fluid as 20%, 30%, 40%, 50%, 60% and 70%, respectively, and analyze the fracture length, height and width as well as the support area and transformation volume of the fracture with different proportions of prepad fluid. From the analysis of the simulation results, it is concluded that the fracture length, height, support area and transformation volume firstly increase and then decrease with the increase of the proportion of prepad fluid, and reach the peak in the range of 50%-60% (Type I reservoir), 40%-50% (Type II reservoir) and 30%-40% (Type III reservoir). Therefore, it is considered that the optimal proportion of prepad fluid is 50%-60% for type I reservoir, 40%-50% for type II reservoir and 30%-40% for type III reservoir. The artificial fracture patterns under the optimal proportion of prepad fluid for the 3 types of reservoirs are shown in Fig. 6.

(a) Type I reservoir



(b) Type II reservoir



(c) Type III reservoir

Fig. 6 Artificial fracture morphology at optimal proportion of prepad fluid for 3 types of reservoirs

## 5. Conclusion

(1) Using the 3D original seismic data body to generate the target layer ant-body, the natural fracture model of ant-body of 3 different reservoir types in Block X of Bozi is generated, which provides the geological basis for the integration demonstration;
(2) Comprehensive dynamic and static data and multidisciplinary methods are used to establish a 1D rock mechanics profile model, combine the geological model with the deep rock-forming theory, establish 3D geomechanical models for 3 different reservoir types in Block X of Bozi, and comprehensively analyze and evaluate the matching relationship between the horizontal stresses and the distribution of fault strikes and tensile natural fractures, so as to provide the geomechanical foundation for the assessment of the integrated reservoirs after remodeling;
(3) Comprehensive geological model and geomechanical model, closely combined with engineering parameters, to establish an integrated true 3D artificial fracture model, on the basis of which the optimization of the parameters

of displacement of fracturing fluid, volume of fracturing fluid, sand proportion research and design was completed, the optimal displacement is considered to be 6-7 ($m^3$/min) for type I reservoir, 5-6 ($m^3$/min) for type II reservoir, and 4-5 ($m^3$/min) for type III reservoir; the optimal fluid volume is considered to be 600-700 $m^3$ of type I reservoir, 600-700 $m^3$ of type II reservoir and 500-600 $m^3$ of type III reservoir; the optimal sand proportion is 15%-20% for type I reservoir, 15%-20% for type II reservoir, and 20%-25% for type III reservoir; the optimal proportion of prepad fluid is 50%-60% for type I reservoir, 40%-50% for type II reservoir and 30%-40% for type III reservoir. Provide guidance for field construction.

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