Research on Economic Evaluation Model and Application of Deep Reservoir Based on Break-even Method

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Abstract. In order to strengthen the economic level of deep reservoir development, this article takes the oil reservoirs in the Zhungeer Basin, Xinjiang as an example, and uses the break-even method to evaluate and analyze the economic benefits of regional reservoir development. Based on the characteristics of the economic structure of reservoir development, a deep reservoir economic evaluation model was constructed and applied to the evaluation of the economic benefits of the reservoirs in the northwestern margin, the southern margin, and the eastern Zhunge. The application results show that the overall economic benefits of the northwestern margin are the highest, and the economic benefits of category A in the south margin are the highest. In order to further improve the economic development level of deep reservoirs, it is recommended to focus on the geology of reservoir distribution in Class I economic reliability areas.

1. Introduction
The exploitation of oilfield resources is an important means of my country's economic development. By exploiting such resources, it can drive the development of other fields [1]. At present, the exploration of shallow and middle oil and gas resources is more difficult, and oil and gas buried below 3,500 m is easier to find [2]. Therefore, my country is experimenting with oil and gas resources below 3,500 m underground. Due to the uneven distribution of oil and gas reserves, it is necessary to evaluate the reserves of various regions in order to improve the economic development level of deep reservoirs [3]. This paper uses the break-even method as a research tool to establish an economic evaluation model for deep reservoirs, and applies it to the Zhungeer Oilfield in Xinjiang for exploration.

2. Overview of deep reservoirs

2.1 Reservoir classification
When exploring the types of oil reservoirs, this article uses the latest resource evaluation categories proposed by China National Petroleum Corporation as the standard to accurately classify the buried depth of Xinjiang oil and gas reservoirs: (1) Shallow layers: oil and gas reservoirs with a buried depth of less than 2000m; The buried depth range is 2000m ~ 3500m; (3) Deep layer: the buried depth range of oil and gas reservoir is 3500m ~ 4500m; (4) Ultra deep layer: The buried depth of oil and gas reservoir is higher than 4500m. [4-5]

During the exploration of Xinjiang oil and gas reservoirs in this study, according to the distribution structure of oil and gas reservoirs in the region, deep oil reservoirs are defined as reservoirs with a burial depth higher than 3000m.
2.2 Exploration of deep reservoirs in the Zhungeer Basin

In this paper, the Zhungeer Basin is used as a deep reservoir exploration site. The number of wellheads in this area with a drilling depth of more than 4500m is about 70. It can be roughly divided into 5 areas to predict oil reserves: (1) Basin 4 well area, the predicted reservoir reserves are about 1906×10^4t; (2) Penshen 2 Well, predicted reservoir reserves are about 5293×10^4t; Xiayan 2 Well, predicted reservoir reserves are about 3993×10^4t; Badaowan Formation, predicted natural gas reserves are 388.66×10^8m^3; Well Jiuyun 1, predicted natural gas reserves 117.52×10^8m^3; Well Mo 10, predicted natural gas reserves 102.09×10^8m^3.

In summary, the deep oil reservoirs in the Zhungeer Basin have large reserves and great development potential. Therefore, selecting this area as a research area for deep reservoir economic evaluation has certain research value.

The Zhungeer Basin has multi-cycle characteristics. For many years, it has been affected by the Himalayan movement and produced different types of traps. These traps are suitable for oil and gas accumulation and their locations are called oil and gas reservoir sites. Due to the relatively low degree of exploration in the basin, seismic survey lines in the hinterland of the area are sparsely distributed. Therefore, the number of traps found in this survey is relatively small. In this study, 74 traps were selected as the economic evaluation objects of deep reservoirs. Among them, there are 28 traps in the northwestern margin; 31 traps in the southern margin; 15 traps in the eastern Zhunge area.

3. Construction of deep reservoir economic evaluation model based on break-even method

3.1. Break-even method

The break-even method is also known as the cost-profit analysis method, which is mainly due to the exploration of the income or output decision-making problem at the critical point of non-loss and unprofitable economic operations [6]. Among them, the critical point is a point at which the profit and loss reaches a balance, which is called the break-even point. Obviously, if the sales volume or production volume is lower than the sales volume (or production volume) corresponding to the equilibrium point, a loss will occur, and vice versa [7-8]. This paper uses the break-even method to evaluate the economic performance of deep reservoir reserves.

3.2. Construction of economic evaluation model for deep reservoir reserves

3.2.1. Estimate of income

Due to the special nature of oilfield exploitation, it is divided into two stages, one of which is the gradual decrease in output, which is called the period of decline in output, and the other stage that the output tends to stabilize, called the period of stabilization of output [10]. With the change of time, the income of the oil field has changed. Among them, the formula for calculating income during stable production period:

\[ R_{es} = \sum_{i=1}^{n_1} N_c \cdot V_p \cdot \left[ P \cdot K \cdot (1 - T_e) \right] \cdot \left( 1 + I_r \right)^{t_i} \]  \hspace{1cm} (1)

The formula for calculating income in decline period:

\[ R_{sd} = \sum_{i=n_1+1}^{n_2} N_c \cdot V_p \cdot e^{-(D_i \cdot t)} \cdot \left[ P \cdot K \cdot (1 - T_e) \right] \cdot \left( 1 + I_r \right)^{t_i} \]  \hspace{1cm} (2)

In formula (1) and formula (2), P represents the crude oil commodity rate, unit: %; D represents the comprehensive decline rate in years, unit: %; NC represents the reserves of economic traps, unit: t; Ir Represents internal rate of return, unit: %; K represents unit price of crude oil, unit: yuan/t; T_e represents comprehensive tax rate, unit: %; VP represents reservoir exploitation speed, unit: %; n represents evaluation period; n2 represents reservoir exploitation Decrease years; n1 represents the stable years of reservoir production.

3.2.2 Estimate of profitable expenditure
Under normal circumstances, profitable expenditures cover many items. According to different periods, it can be divided into two stages of expenditures for estimation:

### Estimated income and expenditure during the production decline period:

$$ R_{gt} = \sum_{i=1}^{n+1} N_{ei} \cdot v_p \cdot e^{-\beta_i} \cdot \left[ C_0 + P \cdot K \cdot A \right] \cdot (1 + I_j)^{-i} $$

(3)

### Estimated income and expenditure during stable production period:

$$ R_{gs} = \sum_{i=1}^{n+1} N_{ei} \cdot v_p \cdot \left[ C_0 + P \cdot K \cdot A \right] \cdot (1 + I_j)^{-i} $$

(4)

In formula (3) and formula (4), $A$ represents the period expense rate, unit: %; $C_0$ represents operating cost, unit: yuan/t.

#### 3.2.3 Estimation of capital expenditure

Expenses in this area can be divided into three investment indicators: production capacity construction, exploration drilling, and exploration seismic [11]. The estimation formula for each expenditure indicator is as follows:

- **Investment estimate for capacity construction:**
  
  $$ I_{ci} = S_{\phi} \cdot f \cdot \left[ h \cdot C_{ei} \cdot \left( 1 + \beta \right) + M \right] $$

  (5)

- **Investment estimate for exploration drilling:**
  
  $$ I_{ij} = N_{ij} \cdot h \cdot (C_{ij} + C_{ej}) $$

  (6)

- **Estimation of exploration seismic investment:**
  
  $$ I_{si} = S_{\phi} \cdot C_{si} $$

  (7)

In formula (6) and formula (7), $I_{ij}$ represents the seismic exploration investment cost, unit: yuan; $C_{ij}$ represents the production capacity construction investment cost, unit: yuan; $C_{ei}$ represents the seismic expenditure per unit area, unit: yuan/km²; $f$ stands for the well pattern density, unit: mouth/km²; $h$ represents the cost of unit footage of a single well for oil testing, unit: Yuan/m; $M$ represents the proportion of water injection wells, unit: %; $h$ stands for the depth of the ground construction cost coefficient, unit: %; on behalf of the exploratory well unit footage expenditure, unit: yuan/m; on behalf of the number of exploratory wells, unit: mouth, if the value is less than or equal to 1, then the value is 1, if it is greater than 1, not greater than 2, the value is 2, and when it is greater than 2, the value is 3.

#### 3.2.4 Establishment of evaluation model

The break-even point in the economic evaluation of deep reservoirs is that the net present value of income is equal to the present value of fixed asset investment. According to the numerical solution formula of the above parameters, the economic evaluation model of deep reservoirs can be sorted out, and the economic reserves of traps can be obtained:

$$ N_e = \frac{1}{V_p} \cdot \left[ \sum_{i=1}^{n+1} \left[ P \cdot K \cdot (1 - T_r) \right] \cdot (1 + I_j)^{-i} + \sum_{i=1}^{n+1} e^{-\beta_i} \cdot \left[ P \cdot K \cdot (1 - T_r) \right] \cdot (1 + I_j)^{-i} - \sum_{i=1}^{n+1} \left[ C_0 + P \cdot K \cdot A \right] \cdot (1 + I_j)^{-i} \right] $$

(8)

#### 3.3 Determination of model parameters

##### 3.3.1 Determination of common parameters and values

During the stable period of oil reservoir development, the parameter values are relatively stable. In this case, the economic calculation values of the reservoirs are the same at all locations. The main parameters and values are as follows: crude oil price, valued at 3500, unit: yuan/t; benchmark Return
rate, value 12, unit: %; water injection well ratio, value 25, unit: %; commodity rate, value 95, unit: %; well pattern density, value 25, unit: mouth/km²; production well drilling Success rate, value 90, unit: %; period expense rate, value 3, unit: %; comprehensive tax rate, value 15, unit: %; exploratory well control reserve area, value 20, unit: km²/well [12-13].

3.3.2. Determination of different parameters and values
The difference parameter refers to the regional difference, and the difference in the oil reservoir production environment in different regions leads to different parameters. In this study, the three regions of Zhundong, South and Northwest are the research objects, and the values of various difference parameters in each region are determined respectively, as shown in Table 1.

| Serial number | parameter name                  | unit    | Cost value            |
|---------------|---------------------------------|---------|-----------------------|
|               |                                 |         | Zhundong | South Rim | Northwest edge |
| 1             | Exploration well test oil       | Yuan/m  | 2490     | 3480      | 2490          |
| 2             | Single well surface construction| Wanyuan / well | 120     | 145       | 130           |
| 3             | Exploratory well drilling       | Yuan/m  | 7020     | 12480     | 5890          |
| 4             | Yield operation                 | Yuan/t  | 540      | 750       | 560           |
| 5             | Area 3D seismic                 | Wanyuan /km² | 175     | 225       | 220           |
| 6             | Oil production rate             | %       | 2.15     | 1.65      | 2.00          |
| 7             | Production well drilling        | Yuan/m  | 2450     | 3870      | 3550          |
| 8             | Decline rate                    | %       | 11       | 14        | 12            |

3.4 Variables and test points value
This model is used to obtain the economic reserves of oil reservoirs, expressed by the symbol of Nc, and the unit is ten thousand tons. There are three model variables, which are internal rate of return, reservoir depth, and trap area. Among them, the internal rate of return variable is represented by the symbol IRR, the value range is 8-20, the unit: %; the reservoir depth variable is represented by the symbol h, the value range is 3000 ~ 7000, the unit: m; the trap area variable is the symbol Sqb. Indicates that the value range is 10 to 110, the value interval is set to 20, and the unit is km².

4. Application analysis of evaluation model in the economic evaluation of deep reservoirs in Xinjiang Oilfield

4.1 Calculation results of economic evaluation of deep reservoir reserves
Using the economic evaluation model designed in the previous section, that is, formula (8), comprehensive evaluation and analysis of the economic performance of deep reservoir reserves in different regions are carried out, and the parameter values and test point values are substituted into the formula, and the following calculation results can be obtained.

4.1.1. Economic evaluation calculation results of deep reservoirs in the northwestern marginal area
In this study, SPSS software was used to sort out parameter data such as the internal rate of return and economic reserves of deep reservoirs in the northwestern margin, and obtain regression accuracy statistics, variance and regression coefficient calculation results, as shown in Table 2, Table 3, and Table 4.

| Serial number | correlation coefficient R | judgment coefficient before adjustment R² | judgment coefficient after adjustment | regression estimation standard error S |
|---------------|---------------------------|-------------------------------------------|--------------------------------------|--------------------------------------|
| 1             | 0.679                     | 0.463                                     | 0.459                                | 0.030                                |
From the statistical results in Table 2, the correlation coefficient corresponding to the trap area, economic reserves, reservoir depth, and internal rate of return is 0.679. From this, it can be judged that there is a strong linearity among the economic calculation parameters of the reservoir in this area. Related features.

Table 3. Variance calculation results of deep reservoirs in the northwestern margin area

| Model number | project name                      | Degrees of freedom | sum of squares | F value | root mean square | associated probability value |
|--------------|-----------------------------------|--------------------|----------------|---------|-----------------|-------------------------------|
| 1            | Residual sum of squares           | 373                | 0.324          |         |                 |                               |
|              | Regression sum of squares         | 3                  | 0.279          | 107.22  | 0.092           | 0.000a                        |
|              | Total sum of squares              | 378                | 0.604          |         |                 |                               |

From the statistical results in Table 3, the associated probability value of deep reservoirs in this area is not higher than 0.001, and the F value is 107.22. It can be inferred from this that there is a linear regression characteristic between the calculation parameters of the reservoir in this area. When the value of the independent variable changes, the dependent variable will also change.

Table 4. Regression coefficient calculation results of deep reservoirs in the northwestern margin area

| model          | Non-standardized coefficient | Regression coefficient t test statistics | standardized coefficient Beta coefficient | associated probability value |
|----------------|------------------------------|-----------------------------------------|-------------------------------------------|-----------------------------|
| Trap area      | 0.000                        | -0.002                                  | -16.635                                   | -1.685                      | 0.000                        |
| constant       | 0.008                        | 0.249                                   | 27.691                                    | 1.954                       | 0.000                        |
| Economic reserves | 0.000                      | 3.830×10⁻⁵                             | 17.940                                   | 1.954                       | 0.000                        |
| Buried depth   | 0.000                        | -2.23×10⁻⁵                             | -13.027                                   | -0.720                      | 0.000                        |

Based on the statistical results in Table 4, a mathematical model of the relationship between various parameters of deep reservoirs in the northwestern margin area is established:

\[ IRR = 0.249 - 0.002 \times 10^{-5} h + 3.83 \times 10^{-5} N_c \]  

(9)

4.1.2. Calculation results of economic evaluation of deep reservoirs in Zhundong area

Use SPSS software to sort out parameter data such as internal rate of return and economic reserves of deep reservoirs in Zhundong area, and obtain regression accuracy statistics, variance and regression coefficient calculation results, as shown in Table 5, Table 6, and Table 7.

Table 5. Regression accuracy table of deep reservoirs in Zhundong area

| Model number | correlation coefficient R | judgment coefficient before adjustment R² | judgment coefficient after adjustment | regression estimate standard error S |
|--------------|---------------------------|------------------------------------------|--------------------------------------|------------------------------------|
| 1            | 0.686                     | 0.475                                    | 0.470                                | 0.0294                             |

From the statistical results in Table 5, there is a strong correlation between the various parameters of deep reservoirs in this area, with a correlation coefficient of 0.686.
Table 6. Variance calculation results of deep reservoirs in Zhundong area

| Model number | project name               | degree of freedom | sum of squares | F value | root mean square | associated probability value |
|--------------|----------------------------|-------------------|----------------|---------|------------------|-----------------------------|
| 1            | Residual sum of squares    | 375               | 0.329          |         |                  | 0.001                       |
|              | Regression sum of squares  | 4                 | 0.274          | 103.98  | 0.093            | 0.000B                      |
|              | Total sum of squares       | 376               | 0.604          |         |                  |                             |

It can be seen from the statistical results in Table 6 that the associated probability of the reservoir model in this area does not exceed 0.001, and the statistic F value is 103.98. It can be inferred from this that there is a linear regression characteristic between the calculation parameters of the reservoir in this area. When the value of the independent variable changes, the dependent variable will also change.

Table 7. Regression coefficient calculation results of deep reservoirs in Zhundong area

| model          | Non-standardized coefficient | Regression coefficient t test statistics | standardized coefficient Beta coefficient | associated probability value |
|----------------|------------------------------|-----------------------------------------|------------------------------------------|------------------------------|
|                | Standard deviation | coefficient                     | t test statistics | standardized coefficient Beta coefficient | associated probability value |
| Trap area      | 0.000                      | -0.002                                  | -16.892                                  | -1.663                       | 0.000                       |
| constant       | 0.008                      | 0.250                                   | 28.069                                   |                               | 0.000                       |
| Economic reserves | 0.000                   | 4.460 × 10⁻⁵                           | 18.279                                   | 1.936                        | 0.000                       |
| Buried depth   | 0.000                      | -2.22 × 10⁻⁵                           | -13.170                                  | -0.729                       | 0.000                       |

Based on the statistical results in Table 7, a mathematical model of the relationship between various parameters of deep reservoirs in Zhundong area is established:

\[
\text{IRR} = 0.250 - 0.002S - 2.22 \times 10^{-5}h + 4.460 \times 10^{-5}N_p
\]  \hspace{1cm} (10)

4.1.3. Economic evaluation and calculation results of deep reservoirs in the southern margin area

Use SPSS software to sort out parameter data such as the internal rate of return and economic reserves of deep reservoirs in the southern margin area, and obtain regression accuracy statistics, variance and regression coefficient calculation results, as shown in Table 8, Table 9, and Table 10.

Table 8. Regression accuracy table of deep reservoirs in the southern margin area

| Model number | correlation coefficient R | judgment coefficient before adjustment R² | judgment coefficient after adjustment | regression estimate standard error S |
|--------------|---------------------------|-------------------------------------------|--------------------------------------|-----------------------------------|
| 1            | 0.674                     | 0.458                                     | 0.452                                | 0.0295                            |

The correlation coefficient in Table 8 is 0.674, and it can be judged that there is a strong correlation between various parameters of deep reservoirs in this area.

Table 9. Variance calculation results of deep reservoirs in the southern margin area

| Model number | project name               | degrees of freedom | sum of squares | F value | root mean square | associated probability value |
|--------------|----------------------------|-------------------|----------------|---------|------------------|-----------------------------|
The statistical results in Table 9 show that the associated probability of the reservoir model in this area does not exceed 0.001, and the statistic F value is 104.28. It can be inferred from this that there is a linear regression characteristic between the reservoir calculation parameters in this area. When the independent variable value changes, the dependent variable changes more significantly.

Table 10. Regression coefficient calculation results of deep reservoirs in the southern margin area

| model          | Non-standardized coefficient | Regression coefficient t test statistics | standardized coefficient Beta coefficient | associated probability value |
|----------------|------------------------------|-------------------------------------------|-------------------------------------------|-------------------------------|
| Trap area      | -0.002                       | -16.445                                   | -1.699                                   | 0.000                         |
| constant       | 0.008                        | 27.409                                    | 1.974                                    | 0.000                         |
| Economic reserves | 2.623 $\times$ 10^{-5}       | 17.690                                    | 0.729                                    | 0.000                         |
| Buried depth   | -2.259 $\times$ 10^{-5}      | -12.991                                   | -0.729                                   | 0.000                         |

Based on the statistical results in Table 10, a mathematical model of the relationship between various parameters of deep reservoirs in the southern margin area is established:

\[
IRR = 0.249 - 0.002 S - 2.259 \times 10^{-5} h + 2.623 \times 10^{-5} N.
\]  

(11)

4.2 Evaluation criteria

4.2.1. Evaluation criteria of geological reliability
This paper uses the grey clustering method to carry out the analysis when evaluating the reserve economy of deep reservoirs. According to different geological reliability, economic evaluation standards are set.
Type I evaluation standard: exploration and development geology has very high reliability;
Type II evaluation standard: high reliability of exploration and development geology;
Type III evaluation criteria: exploration and development geology has less reliability.

4.2.2. Economic reliability evaluation standard
According to the internal economic evaluation requirements of the reservoir development company, the economic reliability evaluation standards are formulated:
Type I evaluation standard: internal return is higher than 16%;
Type II evaluation criteria: the internal income range is 12% to 16%;
Type III evaluation criteria: internal return is less than 12%.

4.2.3. Geological-economic reliability evaluation standard
Class A benefits: Geological reliability and economic reliability are both Class I;
Class B benefits: There are one class I and one class II in geological reliability and economic reliability, or both are class II
Class C benefit: There is at least one Class III in geological reliability and economic reliability.

4.3 Analysis of evaluation results
The SPSS software was used to calculate the economic reserves of oil reservoirs in each area, and the relevant parameter values of each area were substituted into regression model 9, regression model 10, and regression model 11 to evaluate the geological reliability level and economic reliability level of
each area, and then follow The comprehensive evaluation criteria are scored, and the statistical results in Table 11 and Table 12 are obtained.

**Table 11.** The statistical results of comprehensive evaluation traps for deep reservoir reserves in Xinjiang Oilfield (unit: units)

| Area name    | A benefit | B benefit | C benefit | total |
|--------------|-----------|-----------|-----------|-------|
| Northwest edge | 2         | 11        | 15        | 28    |
| South Rim    | 5         | 16        | 10        | 31    |
| Zhundong     | 3         | 7         | 5         | 15    |
| total        | 10        | 34        | 30        | 74    |
| Proportion (%) | 13.51    | 45.95     | 40.54     | 100%  |

The statistical results in Table 11 show that among the 74 traps, there are 10 class A benefit traps, 34 class B benefit traps, and 30 class C benefit traps. Among them, the southern marginal regional trap produces more A-class benefits.

**Table 12.** Xinjiang Oilfield Deep Reservoir Reserve Comprehensive Evaluation Reserve Benefit Statistics Results (Unit: 10^4t)

| Area name    | A benefit | B benefit | C benefit | total |
|--------------|-----------|-----------|-----------|-------|
| Northwest edge | 2211      | 15809     | 23795     | 41815 |
| South Rim    | 6163      | 25620     | 5925      | 37708 |
| Zhundong     | 1739      | 11159     | 3572      | 16470 |
| total        | 10113     | 52588     | 33292     | 95993 |
| Proportion (%) | 10.54%    | 54.78%    | 34.68%    | 100%  |

From the statistical results in Table 12, the reserves of deep reservoir traps in Xinjiang are divided into three types of beneficial reserves. Among them, Type B benefit reserves account for the largest proportion, accounting for 54.78% of the total, and the corresponding total reserves are 52588 × 10^4t. Category C benefits ranked second, accounting for 34.68% of the total, and corresponding total reserves were 33292 × 10^4t. Type A effects account for the smallest proportion of the total, with a value of 10.54%, which corresponds to a total reserve of 10113 × 10^4t. Among them, the northwestern margin has the highest economic benefit.

5. **Recommendations for deep reservoir management**

By constructing a reservoir economic evaluation model, this article can more clearly grasp the economic benefits of reservoir development in various regions, and help guide the development of reservoirs. The economic reliability evaluation standard is involved in the set evaluation standard. If the evaluation result of this index is Class I and the grade of the geological evaluation result is Class II or Class III, then it cannot be ignored when exploiting oil fields. This area should be further surveyed to fully grasp the geological structure of this area, improve the level of mining technology, and obtain higher economic benefits.

6. **Conclusion**

This paper selects the break-even method as the research tool, and takes the oil reservoir economic evaluation of the Zhungeer Basin in Xinjiang as the research content. By constructing a deep reservoir economic evaluation model, comprehensive evaluations of the economic benefits of the oil reservoirs in the northwestern margin, southern margin, and Zhundong regions were made. The evaluation results show that the overall economic benefits of the northwestern margin are the highest, and the economic benefits of category A in the south margin are the highest. In order to further enhance the economic benefits of deep reservoir development, this paper gives some management suggestions based on the evaluation criteria.
7. References

[1] Hou Tianhong, Yu Gaoming. Research and Application of Reservoir Numerical Simulation Model Reduction Method[J]. Liaoning Chemical Industry, 2018, 47(11): 1165-1167.

[2] Zhang Xiaohua. Calculation method of limit production and water cut of oilfield developed by dividing model[J]. Journal of Petrochemical College, 2019, 32(4): 93-98.

[3] Xue Zhibo, Chen Wei. Technical and economic evaluation of Laos Paben gold mine based on break-even analysis[J]. China Science and Technology Investment, 2018(6): 162-163, 199.

[4] Zheng Bin, Yang Xingping, Shi Yi, et al. Establishment and application of economic evaluation model for foreign cooperation projects in the middle and late stages of oil reservoir development[J]. China Mining Industry, 2020, 29(5): 37-41.

[5] Zhang Lixin, Li Tiancheng, Wang Lei. Application of break-even analysis in technical and economic evaluation of mining projects[J]. Mineral Exploration, 2019, 10(1): 131-135.

[6] Li Xi. Application of break-even analysis methods in construction projects[J]. Shangqing, 2018(12): 216-218.

[7] Cui Pengxing, Liang Weiwei, Lin Jianwu, et al. Research on contribution of natural imbibition in low permeability reservoirs and application of normalized recovery model[J]. Unconventional Oil & Gas, 2018, 5(3): 63-67, 51.

[8] Li Shuijing. A method for updating geological reserves based on a three-dimensional geological model——Taking M reservoir as an example[J]. Inner Mongolia Petrochemical Industry, 2019(5): 54-55.

[9] Du Chunhui, Qiu He, Chen Xiaofan, et al. Application of flow potential analysis technology based on numerical simulation in fractured-vuggy reservoir development[J]. Petroleum Reservoir Evaluation and Development, 2020, 56(2): 87-93.

[10] Wang Jianguo, Shen Huanwen, Qiu Yixin, et al. Feasibility analysis of the interwell dynamic connectivity inversion model based on multiple linear regression——Taking Chang 6 reservoir in Wuliwan 1st block of Jing'an Oilfield as an example[J]. Unconventional Oil & Gas, 2019, 6(2): 57-62.

[11] Zhang Yangyang, Guo Min, Liu Zhihui, et al. Research on quality control of 3D geological model of oil reservoir——Taking block E of D oilfield as an example[J]. Natural Gas and Petroleum, 2020, 38(1): 72-78.

[12] Liu Yongge, Yao Chuanjin, Fu Shuishi, et al. Practice and understanding of 5E teaching mode for reservoir numerical simulation based on visualization experiment[J]. Education Teaching Forum, 2020(22): 388-390.

[13] Zhao Qingfei, Fan Zheyuan, Zheng Xiangke, et al. Construction of rapid evaluation model for different types of reservoir development indicators in the new Sinopec area[J]. Petroleum Geology and Recovery Efficiency, 2019(4): 77-81.