Research on Optimal Utilization of Proven Undeveloped Gas Field

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Abstract: X gas field shows a large scale of proven unexploited reserves, however, most of them are characterized by low gas well production, rapid pressure decline, small well control reserves and poor economic benefits. How to economically and orderly develop and utilize these reserves is a difficult problem. By establishing an evaluation system for the existing developed blocks of X gas field, applying the method of multiple regression, establishing a comprehensive evaluation and scoring formula for development effect, taking the proven index data of the development block into the formula for calculating, the comprehensive evaluation score of development and utilization of unexploited reserves blocks, queuing the blocks with productivity and reserves in the new area. This method will provide technical reference for the next development and utilization of X gas field.

1. INTRODUCTION
X gas field shows a large scale of proven unexploited reserves, this accounts for about 50% of the submitted proven reserves. Undeveloped gas reservoirs have various lithology and lithofacies types, the plane and longitudinal’s changes are fast. The heterogeneity is strong, which is controled by structure and lithology, gas and water’s relation is complex, gas wells have low production, rapid pressure decline and every well’s control reserves is small, poor economic benefits, difficult development and so on. In order to make rational use of this part of resources and give full play to its production potential, it must be evaluated and optimized scientifically.[1]

The process of evaluation and optimization of unexploited reserves is very complicated, it is often difficult to determine for makers. In this article, based on the technical and economic indicators of the development block, a comprehensive evaluation system of development effect indicators is established. The correlation between each index and the development effect is analyzed, determining the weight of each evaluation index, carrying out the studying on empirical formula for comprehensive evaluation of development effect, the scoring method of comprehensive evaluation of unexploited reserves is obtained. The datum of unexploited reserves blocks are substituted, to calculate and sort them, this will provide a reliable basis for decision makers to organize production.

2. EVALUATION OF DEVELOPMENT EFFECT AND REGRESSION OF EMPIRICAL FORMULA
The development practice of developed blocks has important guiding significance for the effective utilization of reserves in undeveloped blocks[2]. The evaluation steps are: First of all, we must judge the development effect of the developed zone, determining the specific indicators of development effect evaluation; Secondly, the expert experience method is used to comprehensively judge the development effect of the developed block by comprehensive technology and economic factors, on this basis, the
correlation between development effect and various factors such as reservoir and fluid properties are analyzed; Finally, based on the actual data, the influencing factors\(^3\) are screened, their weights are determined, and the regression empirical formula is determined.

### 2.1. Development effect evaluation by experience method

According to gas reservoir development’s classification index limit and economic evaluation index, combining with expert experience, comprehensive development of technical indicators and economic evaluation indicators\(^4\), five main affecting factors of the development effect are determined. This is used to evaluate the development effect of the four developed blocks of the X gas field one by one and score them quantitatively. Through scoring the development technology and economic evaluation of A, B, C, D Blocks, the final comprehensive score is 78 points, 77 points, 84 points, 59 points (Table 1).

**Table 1 Scoring table for effect evaluation of A, B, C, D blocks**

| Serial number | Evaluation category | Evaluation index | score (points) | Actual value | score (points) |
|---------------|---------------------|-----------------|----------------|-------------|----------------|
| 1             | Development Technology category | Average daily gas production of single well (10^4 m^3) | ≥10 9 | 5~10 <5 6.3 2 | 7.6 10 4.5 4.5 | 75 75 90 55 |
| 2             | Stable production period (a) | ≥10 9 | 5~10 <5 7 | 10 9 | 7 9 | 75 75 90 75 |
| 3             | Recovery ratio (%) | ≥40 42 6 | 35~40 42.1 | 37 75 | 32.2 3 | 90 90 75 55 |
| 4             | Payback period of investment (a) | <4 7.5 | 6~8 6.5 7 | 3.9 5 | 9.82 75 90 55 |
| 5             | Internal rate of return (%) | ≥30 33.5 | 20~30 24.6 | 18.1 | 12.2 2 | 75 55 90 55 |

**Table 1 Scoring table for effect evaluation of A, B, C, D blocks**

### 2.2. Screening and correlation analysis of influencing factors

**2.2.1. Basic evaluation index set**

Undeveloped blocks only have initial reservoir, fluid properties and preliminary economic evaluation data, unlike the existing development zones, they have rich technical and economic evaluation indicators, therefore, the influencing factor indicators can only be established by such static indicators. This is named a basic evaluation index set. The determination of basic evaluation index set depends on expert experience, it should also be considered that the relationship between some indicators and development results are not clear, therefore, the scope of basic evaluation index set should be appropriately expanded. According to preliminary analysis, the basic evaluation indicators of X gas field are as follows: the basic evaluation index set include geological reserves, reserve abundance, reservoir thickness, buried depth in the middle of oil layer, effective porosity, internal rate of return, formation viscosity, daily gas production per thousand meters well, effective permeability.

On this basis, through comprehensive and relevant research, the influencing factors of the index
which have strong correlation with the expert scoring index are screened out.

2.2.2. Screening and correlation analysis of influencing factors

The basic tables are formed by the expert’s scoring and basic evaluation index of developed blocks, the results are showed in table 2.

Table 2  Basic table of evaluation system of development effect index in developed areas

| Block | Expert scoring (points) | Geological reserves (10^8 m³) | Reserve abundance (10^8 m³/10^2 km^2) | Middle depth of gas reservoir (m) | Porosity (%) | Permeability (mD) | Daily gas production per thousand meters well (10^4 m³) | Internal rate of return (%) |
|-------|------------------------|-------------------------------|--------------------------------------|--------------------------------|--------------|-----------------|-------------------------------------------------|-----------------------------|
| A     | 78                     | *                             | 7.3                                  | 2946                           | 8.4          | 1.19            | 2.61                                            | 24.6                        |
| B     | 77                     | *                             | 8.85                                 | 3547                           | 6.57         | 0.43            | 1.78                                            | 18.1                        |
| C     | 84                     | *                             | 13.28                                | 3688                           | 10.8         | 1.31            | 2.76                                            | 33.54                       |
| D     | 60                     | *                             | 6.42                                 | 3804                           | 5.37         | 0.14            | 1.18                                            | 12.22                       |

On the basis of table 2, we have made a correlation analysis between each basic evaluation index and expert score. Geological reserves, reservoir thickness and well depth are irrelevant to expert score. Reserve abundance, porosity, permeability and daily gas production per thousand meters well have a linear correlation to expert score (Figure 1~Figure 2).

Therefore, reserve abundance, porosity, permeability and daily gas production per thousand meters well are regarded as four important factors affecting the development index evaluation system.
2.3. **Weight analysis of influencing factors**

2.3.1. **Determination of the weight of influencing factors**

The weight of influencing factors is a comprehensive measure of subjective evaluation and objective response of the relative importance of each index in the development effect evaluation system. In this paper, multiple regression method\[^5\] is used to determine the weight of each influencing factor. S is set to the expert score, F, K, Q are set to influence factor, their dependent variables are f, k, q. The weight of each factor is \(a_1, a_2, a_3\), the constant term is \(b\). According to the influencing factors and the trend of expert score, the score is calculated.

\[S = a_1 F + a_2 K + a_3 Q + b\]

Using the actual data of developed units, \(a_1, a_2, a_3\) and \(b\) are calculated by using multiple regression method, the scoring \(S\) formula is determined.

\[S = a_1 F + a_2 K + a_3 Q + b = 0.29(26.03\ln f + 18.68) + a_2(15.18k + 63.09) + a_3(12.54q + 48.63) + 8.36\]

3. **PRODUCTION SEQUENCING OF UNDEVELOPED RESERVES EVALUATION**

The proven unexploited reserves in deep layers are distributed in nine blocks. The actual datum (reserve abundance, permeability and daily gas production per thousand meters well) of these blocks are substituted into the empirical formula of expert scoring. According to the actual score value, the evaluation and production order of the nine proven unused blocks in depth are determined. On the premise that its internal rate of return reaches the industry benchmark rate of return, five blocks are selected as alternative blocks for the next development.

4. **CONCLUSION**

(1) The undeveloped gas reservoirs are optimized and sorted for orderly production construction, it is of great practical significance to formulate the development plan and alleviate the contradiction of tight reserve replacement.

(2) The evaluation of unexploited reserves is a comprehensive evaluation technique, the evaluation results provide a basis for decision-making of development investors. It is the inevitable trend of this work in the future to constantly improve and deepen the evaluation technology and improve the credibility of the evaluation.

(3) The development practice of developed areas has guiding significance for the effective use of undeveloped reserves. Some economic evaluation factors of gas field development have been comprehensively considered, which will establish evaluation standards through development blocks. Using the method of multiple regression, the scoring formula of comprehensive evaluation of development effect is established, optimizing the queue for undeveloped blocks and guiding the optimal utilization of undeveloped reserves. The practical application results show that this method is suitable for the practice of X gas field.

**Author Introduction**

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