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Resource Estimation of the Goaf Area in Shoushan Mine

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ABSTRACT

Starting with the exploration data of coalbed methane (CBM) in the Shoushan block, this study analyzes the distribution of the main coal seam and the layout of the mined-out wells in the coal-bearing strata of this area. The main coal seam in this block belongs to the Permian system. It is characterized by considerable thickness and high gas content. According to the relevant industry standards for calculating CBM volume, and based on the data from drilled wells, the estimated CBM resources are approximately 2.5×10^8 m³, with a resource abundance of 0.46×10^8 m³/km², indicating favorable prospects for CBM development in this block.

KEYWORDS

Mined-Out Wells; Coalbed Methane (CBM); Gas Content; Estimation.

1. INTRODUCTION

Coalbed methane (CBM) is a type of gas generated during the coalification process[1], which involves the geophysical and chemical transformation of peat or sapropel into coal, including coal diagenesis and metamorphism[2]. It is primarily adsorbed within coal seams and is predominantly composed of methane (CH_4). CBM is a high-quality energy source and a fundamental raw material for the chemical industry, characterized by its high calorific value, low pollution, and high safety. It serves as an essential supplement to conventional geological energy sources such as oil and natural gas. The development and utilization of CBM are of great significance in alleviating China's tight oil and gas supply situation and reducing greenhouse gas emissions.Shoushan No. 1 Mine is located in Henan Province. In recent years, relevant departments have conducted extensive exploration and development work on the CBM reservoirs in this area[3]. During the drilling process, gas logging has revealed significant CBM displays, and the test discharge results have been relatively promising, indicating favorable prospects for CBM development in this region. Therefore, it is necessary to conduct a detailed study of the geological characteristics and reserves of this area.

2. ESTIMATION SCOPE

Shoushan Mine No. 1 includes the Ji-1 mining area, Ji-2 mining area, and Wu-1 mining area. Based on the mining history of Shoushan Mine No. 1, the resource estimation scope primarily focuses on the Ji-1 and Ji-2 mining areas. The specific boundaries and calculation scope are as follows:

Northern Boundary: Bounded by the northern edge of the Ji15-17-11061 working face in the Ji-1 mining area.

Southern Boundary: Bounded by the lower edge of the Ji-2 mining area.

Eastern and Western Boundaries: Bounded by the heading faces of the mining panels.

Mining Elevation: Between 600 meters and 750 meters.

Area Dimensions: Approximately 3.9 kilometers in the east-west direction and 1.9 kilometers in the north-south direction.

Specifically, the calculation is based on the goaf areas, including statistics for 1 goaf area in the Ji-1 mining area, 11 goaf areas in the Ji-2 mining area, and 2 replacement areas in the Ji-2 mining area.

Table 1: Coordinates of Range Inflection Points

PointNumber	X	Y	Point Number	X	Y
f1	38441902.5	3739519	f9	38443312.2	3739010
f2	38441899.6	3739325	f10	38444310.6	3739077
f3	38442923.1	3739304	f11	38444323.5	3738868
f4	38442894.5	3739501	f12	38444593.6	3738877
f5	38441083.4	3738989	f13	38444604.1	3738698
f6	38441155.1	3737812	f14	38444975.2	3738721
f7	38442619.2	3737758	f15	38445018.4	3737992
f8	38442520.8	3738919	f16	38443471	3737882

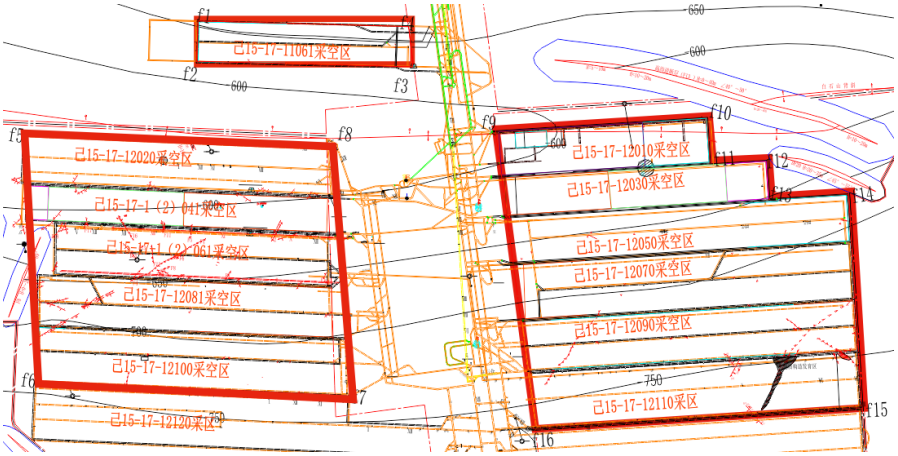

Figure 1. Statistical Diagram of Resource Range in the Mined-out Area

3. ESTIMATION METHOD

The coalbed methane resources in the goaf area are equal to the sum of the free gas in the goaf space, the free gas in the caved zone, and the free gas in the fractured zone, that is:

$$Q_c = Q_y + Q_m + Q_1 \tag{1}$$

Where:

(Qc): Total CBM resources in the goaf area (in 10^8 m^3).

(Qy): Free gas in the goaf space (in 10^8 m^3).

(Qm): Free gas in the caved zone (in 10^8 m^3).

(Q1): Free gas in the fractured zone (in 10^8 m^3).

3.1. Free Gas in the Goaf Space

The free gas in the goaf space is composed of the gas associated with the coal recovery rate and the gas released during the coal mining process that remains in the goaf. The coal recovery rate is

estimated at 85%, and the gas release rate from the coal left in the goaf is assumed to be 10%. This can be expressed as:

$$Q_y = (1-\eta_1+\eta_2)\times S_c \times H_c \times D_c \times C_c / \cos\alpha / 10000 \quad (2)$$

Where:

Coal recovery rate: 0.85 (taken in this case).

Gas release rate: 0.10 (taken in this case).

3.2. Estimation of Free Gas in the Caved Zone and Fractured Zone

The free gas in the caved zone and fractured zone originates from the sandstone gas in the roof of the No. 2-1 coal seam, located at a depth of 40-80 meters. The gas emission rate from the adjacent layers is determined based on the relationship between emission rate and interlayer distance, as illustrated in Figure 2.

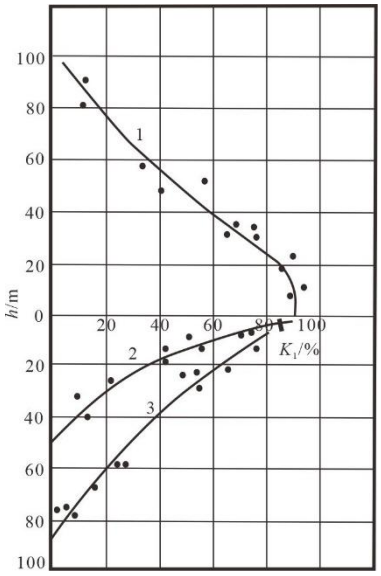

Figure 2: The Relationship Curve Between the Emission Rate of Adjacent Layers and the Interlayer Distance

The estimation formula for the amount of in the caved zone and fractured zone is as follows:

$$Q_m + Q_1 = \eta_3 Q_w \quad (3)$$

In the formula:

The gas emission rate of the coal adjacent layer: The average value **0.40** is used this time;

(Qw) **The gas resource volume of the surrounding rock sandstone**: Unit is **(108m3)**.

These parameters are crucial for accurately estimating the gas resource quantity in the caved and fractured zones.

The estimation method and parameter determination for coalbed methane resources in the un-mined area are the same as those for the replacement area. The replacement area needs to be determined based on the mining plans of each individual mine.

4. ESTIMATION RESULTS

Based on the resource estimation method for the goaf area, the scope of resource estimation for the goaf area was delineated. The area of the goaf was calculated, along with the heights of the caved zone and fractured zone. The estimation results of the coal-measure gas resources in the goaf of the No. 2-1 coal seam in the Shoushan No. 1 Mine are shown in the table below.

Table 2. Estimated Coal-Measure Gas Resources in the Goaf of the No. 2-1 Coal Seam in Shoushan No. 1 Mine

Goaf							
Name	Planar Area, km^2	Coal Seam Dip Angle°	Inclined Area, km^2	Apparent Density, t/m^3	Coal Seam Thickness/ m	Gas Content m^3/t	Resource Quantity $108m^3$
Volume of Free Gas in Goaf	5.26	15	5.45	1.35	5.73	20	2.11
Volume of Gas Migrating from Surrounding Rock to Goaf	5.26	15	5.45	2.55	10.89	0.65	0.39
Total Volume			5.45				2.50
Resource Abundance/$108m^3/km^2$							0.46

5. SUMMARY

5.1. Summary

From the table, it can be observed that the coalbed methane resources and resource abundance of the No. 2-1 coal seam in the goaf of Shoushan No. 1 Mine are as follows:

1. Coalbed Methane Resources

- The coalbed methane resources in the No. 2-1 coal seam of the goaf of Shoushan No. 1 Mine amount to 2.5×10^8 m^3.

This figure represents the total amount of coalbed methane released or stored during the mining process of this coal seam, reflecting the potential development value of coalbed methane in this area.

2. Resource Abundance

The resource abundance of the No. 2-1 coal seam is 0.46×10^8 m^3/km^2.

- This value indicates the distribution density of coalbed methane resources per unit area, providing a measure of the concentration and potential economic viability of the resources in the region.

These metrics are critical for evaluating the feasibility of resource exploitation and optimizing mining strategies.

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