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# Research on the gas storage law of M7$_{lower}$ coal seam in Yuka No.1 coal mine

**Xuezhan Xu** [1,2,3]

[1]*School of Safety Science and Engineering, Anhui University of Science & Technology, Huainan, China*
[2]*State Key Laboratory of Coal Mine Disaster Prevention and Control, Chongqing, China*
[3]*CCTEG Chongqing Research Institute, Chongqing, China*

***Abstract:*** *The gas situation in the M7 $_{lower}$ coal seam in the No.1 coal mine of Yuka has only been reported by the appraisal report of the gas level, and the results of the gas accumulation situation in this seam are in a blank state. In order to ensure the safety of mining the coal seam under M7 $_{lower}$, the basic parameters of gas in this seam are examined, and the influence factors of burial depth and structure on gas pressure and gas content are studied. The results of the study show that: the closed structure of backslope leads to an increase in gas content and gas pressure, and the open structure of faults and other faults leads to a decrease in gas pressure and gas content; and empirical formulas are established for gas pressure-buried depth and gas content-buried depth. The research results and methods are of great significance for the study of gas storage in other mines.*

***Keywords:*** *gas accumulation; burial depth; gas pressure; gas content; tectonics*

## 1. Introduction

Gas disasters occur from time to time in the process of coal mine production, and gas exists in the form of free state and adsorption state in the coal seam, and the study of gas storage law is of great significance to further improve the comprehensive management of gas. Our experts and scholars have carried out a lot of research on the issue of the gas storage law, and have achieved fruitful results. Li Weiwei [1] for the Datong coal mine 3 # coal seam gas storage law research, through the mining process back to the face of the gas outflow and the original coal seam gas content of the examination, put forward the influence of the coal seam gas change law of the main factors for the geological structure and the original gas content, according to the distribution of gas to draw out the coal mine mining area gas geologic map for the later mining to provide a better basis for the data; Li Wenzhen [2] conducted a study on the gas accumulation law of Dahuangshan No.1 well, and proposed the influence of geotectonic features on the gas accumulation law, and the results showed that there is a gas aggregation effect in the fault area; Yang Yichao, Xu Hongjie, Liu Huihu, et al. [3] put forward a multifactor catastrophe theory for the gas accumulation in the No.10 seam of Luling Mine, and evaluated the influence on the size of the gas accumulation according to the different conditions, and the results showed that: geological conditions are the main factors of the gas distribution, and the original gas content was mapped out according to the distribution of the gas, which provides better data for later mining. The evaluation results show that the geological conditions are the primary factors affecting the gas storage situation. The previous research results mainly focus on the low altitude areas where the gas storage is relatively stable, and there are fewer researches on the gas storage rules of coal seams in high altitude areas with complex tectonic devices[4-6]. Yuka No.1 coal mine is located in Dachaidan area of Qinghai Province, with high altitude and complex geological structure, in order to understand the gas storage law of M7 $_{lower}$ coal seam in this mine, we are now carrying out a practical research on the gas storage situation of this coal mine.

## 2. Project Information

Yuka No.1 coal mine is subordinate to Qinghai Energy (Development) Group Co., Ltd, with an authorized production capacity of 4 million t/a. The mineable coal seams are M5, M7 $_{upper}$, M7 $_{middle}$ and M7 $_{lower}$ seams, with the average thickness of the seams of 5.12m, 10.18m, 13.92m and 19.47m, respectively, among which M7 $_{upper}$, M7 $_{middle}$ and M7 $_{lower}$ seams have complex structure and the thickness of the seams varies a lot. According to the appraisal results of the mine's gas level, the maximum gas outflow from the mine's boring face is 0.59m$^3$/min, the maximum gas outflow from the coal face is 1.18m3/min, and the maximum gas outflow from the mine is 12.98m$^3$/min, which makes the mine a high-gas mine. The propensity of spontaneous combustion of the coal seam is class II spontaneous combustion, and the coal dust is explosive with no impact low pressure. Regarding the industrial analysis of coal, the initial velocity of gas discharge (△p), the solidity coefficient of coal (f), the truth to the density, apparent density, porosity, gas adsorption constants (a, b) parameter content are all relevant measurements, and there is no research on the content of the regional gas pressure, the original gas content, and the gas law. The M7 $_{lower}$ Seam is an active coal seam.

## 3. Gas Parameter Examination

### *3.1. Parameter testing*

Three samples were taken in the area of the coal seam under M7 $_{lower}$ coal seam and sent to the laboratory for industrial analysis of coal, determination of parameters such as initial velocity of gas dissipation (△p), coefficient of coal firmness (f), truth-to-density, apparent density, porosity, and gas adsorption constants (a, b), etc.

The sampling points are +2750 west wing machine-track unity alley, +2400 level 1# sub-shaft extension depth 3# contact alley. The measured basic parameters are shown in Table 1.

*Table 1: Test results of basic parameters of M7 $_{lower}$ coal seam.*

| sampling location | Industrial analysis(%) | | | TRD (t/m$^3$) | ARD (t/m$^3$) | F (%) | adsorption constant | | gas discharge initial velocity△p(mmHg) | f |
|---|---|---|---|---|---|---|---|---|---|---|
| | $M_{ad}$ | $A_d$ | $V_{daf}$ | | | | a (cm$^3$/g) | b (MPa$^{-1}$) | | |
| 1# | 8.90 | 19.88 | 34.44 | 1.60 | 1.44 | 10.39 | 34.68 | 0.88 | 10.20 | 0.93 |
| 2# | 10.49 | 11.99 | 38.97 | 1.53 | 1.34 | 12.92 | 36.17 | 0.73 | 15.30 | 0.59 |
| 3# | 8.66 | 8.30 | 40.31 | 1.43 | 1.26 | 11.66 | 35.11 | 0.82 | 10.20 | 1.53 |

According to the analysis of the basic parameters of the coal seam, it can be seen that the hardness of the M7 $_{lower}$ coal seam is larger, the gas discharge initial velocity is more than the critical value of 10mmHg, and the coal quality is better on the whole.

### *3.2. Examination of gas pressure and content*

The methods of measuring gas pressure in the original coal seam mainly include direct method and indirect method. The direct method is to construct boreholes to the measuring points arranged in the coal-bearing area, seal the boreholes tightly, and connect the external pressure gauge to measure the pressure continuously. The indirect method is to measure the gas permeability system, gas content coefficient curve and other data to infer the gas pressure. In order to ensure the accuracy of the pressure test, the direct method was used to determine the gas pressure in the M7 $_{lower}$ coal seam of Yuqa Mine, and three points were drilled for pressure measurement.

In the process of pressure measurement, the arrangement of pressure measurement points should avoid the tectonic area, and the pressure measurement equipment mainly includes: pressure gauge, grouting pipe, φ15mm iron pipe, cement, pipe joints and mine grouting pump. Pressure measurement steps are as follows: (1) install the pressure measurement pipe, and seal the empty mouth with polyurethane; (2) inject the cement slurry with expansion agent from the grouting pipe; in order to prevent the hole from falling into the pressure measurement pipe and other drilling debris, resulting in pipe blockage, the end of the pressure measurement hole is sealed with a three-layer cotton gauze, which ensures the air permeability and at the same time effectively prevents the broken rock inside the borehole from falling into the borehole.

In the pressure measurement area, samples were taken during the drilling process to directly test the gas content in the coal seam, and the gas content testing method was the direct detection method, using the DGC Gas Content Direct Determination Instrument for measurement. Through comprehensive testing, the gas pressure and gas content of M7 $_{lower}$ coal seam were measured as shown in the table below.

*Table 2: Measurement results of gas pressure and gas content.*

| Measurement point location | depth of burial(m) | gas content($m^3$/t) | gas pressure(MPa) |
|---|---|---|---|
| 2850 Transportation Shunnel (East) Mileage 450m | 367.8 | 1.15 | 0.14 |
| 2750 West Alley 1400m | 354.8 | 1.82 | 0.33 |
| 2400 Level 1 Extended Depth Downhill Chamber 4 | 577.2 | 2.15 | 0.36 |
| 2400 Extended depth 3# contact lane | 548.3 | 1.02 | 0.11 |
| 2750 Machine-Track Combined Alley (former substation entrance) | 417.1 | 1.25 | 0.16 |
| 2400 Level #2 Sub-shaft Track Downhill (Chamber 13) | 679.8 | 2.23 | 0.4 |

## 4. Analysis of gas accumulation law

### *4.1. Influence of geological structure*

The influence of geological structure on gas content and gas pressure is qualitative analysis. According to the measured data combined with the tectonic situation of the region, it can be seen that the overlying rock layers of the closed and complete backslope tectonic region are poorly permeable strata that can form gas storage structure, therefore, although the depth of burial of the 2750 west wing aisle is small, but the gas pressure and gas content is greater than that of other regions; the large fault structure can release the gas, which leads to the gas content and gas pressure are relatively low. Large fault structure can release gas, resulting in low gas content and gas pressure. The measuring point of Extended depth 3# contact lane depth is relatively deep, but the gas pressure and gas content are relatively low.

### *4.2. Influence of burial depth*

The effect of burial depth on gas pressure and gas content can be analyzed quantitatively, as the data of measurement point burial depth is more accurate. According to the measurement results, the buried depth interval of the measuring point of gas pressure and gas content in the $M7_{lower}$ coal seam is 354.8~679.8m, the value of gas content is 1.02~2.23$m^3$/t, and the gas pressure is 0.11~0.4MPa, and according to the mathematical relationship between the buried depth of the measuring point and the gas pressure and gas content, the relationship between the gas pressure and the buried depth was obtained from fitting, and the relationship between gas pressure and the buried depth was as shown in Table 3, the relationship diagram is shown in Figure 1; the relationship between gas content and the buried depth was as shown in Table 4, the relationship diagram is shown in Figure 2.

*Table 3: Statistical table for fitting multiple relationships between burial depth and gas pressure in the $M7_{lower}$ coal seam.*

| Comparison Program | linear relationship | logarithmic relationship | index relationship | power relation |
|---|---|---|---|---|
| Fitting of the relational equation | $y=0.0009x-0.2274$ | $y=0.4671\ln(x)-2.6523$ | $y = 0.0347e^{0.0036x}$ | $y=0.0021x^{1.7342}$ |
| $R^2$ | 0.9347 | 0.9246 | 0.9079 | 0.9296 |

*Table 4: Statistical table for fitting multiple relationships between burial depth and gas content in the $M7_{lower}$ coal seam*

| Comparison Program | linear relationship | logarithmic relationship | index relationship | power relation |
|---|---|---|---|---|
| Fitting of the relational equation | $y=0.0033x-0.018$ | $y=1.5548\ln(x)-7.9435$ | $y =0.5536e^{0.0022X}$ | $y=0.003x^{1.0153}$ |
| $R^2$ | 0.9271 | 0.9027 | 0.9007 | 0.9169 |

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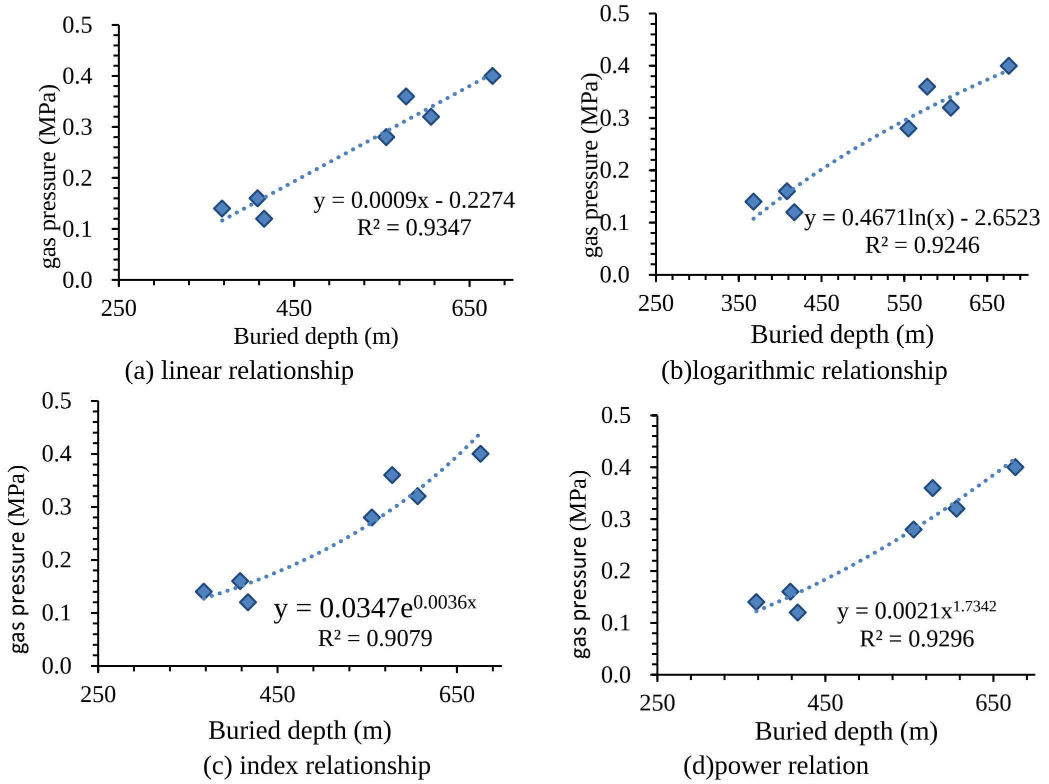


*Figure1:Fitted gas pressure vs. burial depth for M7 $_{lower}$ coal seam*

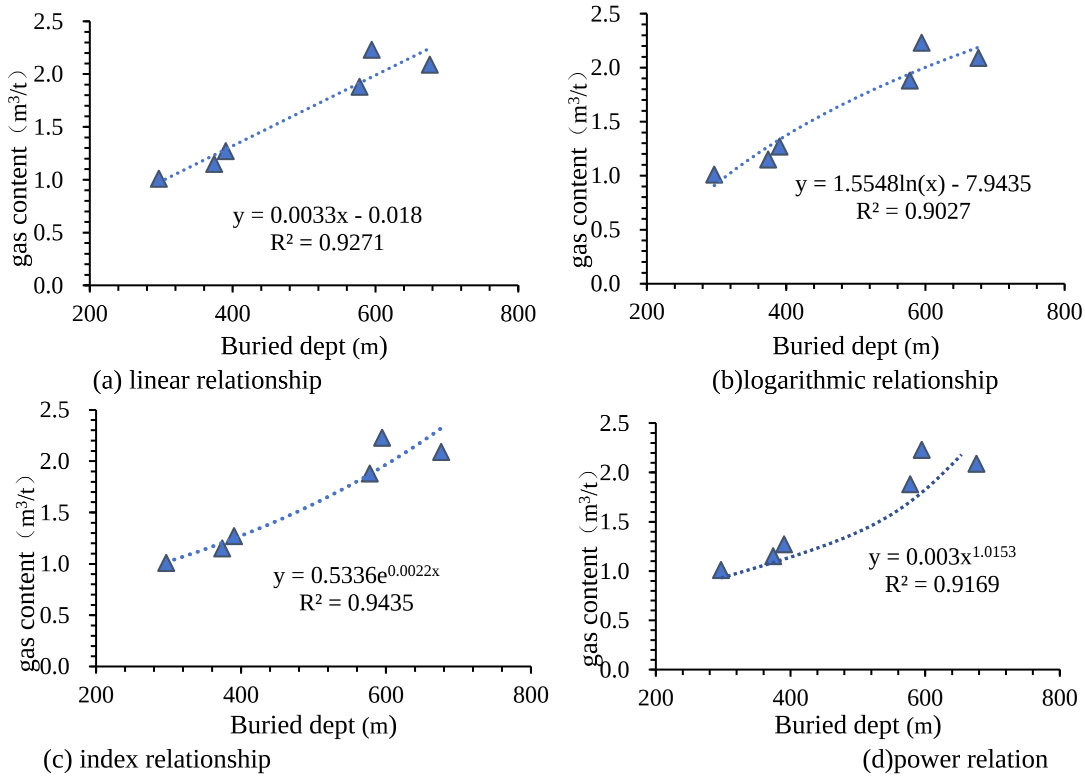


*Figure 2: Fitted gas content vs. burial depth for M7 $_{lower}$ coal seam.*

According to the results of data analysis, the best fit in the fitting relationship between gas pressure, gas content and depth of burial is the linear relationship, and the prediction equations between gas pressure-depth of burial and gas content-depth of burial are as follows:

$$\mathbf{P = k(0.0009H - 0.2274)}$$

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$$\mathbf{W = f(0.0033H - 0.018)}$$

In the formula:

P—M7 $_{lower}$ coal seam gas pressure under, MPa;

H—Buried depth, m;

k—The coefficient of influence of structure on gas pressure. When P is the gas pressure in tectonic-free area, the value of k is taken as 1; when P is the gas pressure in closed tectonic area, the value of k is taken in the range of 1.5~1.57; when P is the gas pressure in open structure, the value of k is taken in the range of 0.56~0.75;

W—M7 $_{lower}$ coal seam gas content, $m^3$/t;

f— tectonic influence coefficient on the gas content, W for the gas content of the tectonic-free area, f takes the value of 1; W for the gas content of the closed tectonic area, f takes the value in the range of 1.08~1.39; W for the gas content of the open tectonic area, f takes the value in the range of 0.55~0.65.

## 5. Conclusion

In order to prevent the occurrence of gas disaster during the mine's mining, the study on the gas distribution situation of the M7 lower coal seam in Yuka No.1 coal mine was carried out, and the following conclusions were obtained:

(1) It is known by the results of comprehensive parameter measurement of $M7_{lower}$ coal seam that the coal quality of $M7_{lower}$ coal seam is good and hard;

(2) The method of measuring gas pressure and gas content is introduced, and the values of gas content in the area are 1.02~2.23m3/t and gas pressure is 0.11~0.4MPa;

(3) The comprehensive analysis shows that the closed structure of backslope leads to the increase of gas content and gas pressure, and the open structure such as fault leads to the decrease of gas pressure and gas content; the empirical formulas of gas pressure-buried depth and gas content-buried depth are established.

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