

# Relationship between Maceral of Coal and Coal-bed Methane adsorption ability in Sihe Coalmine of Qinshui Basin, China

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**Abstract.** Maceral components and its content of coal were divided based on the microscopic characteristics of coal. The Langmuir volume and the Langmuir pressure were tested, and the Langmuir volume represents the adsorption capacity of coal. The formation of coal bed methane is affected by the partition of the maceral components in coal. Therefore, the relationship between maceral composition and coal bed methane adsorption capacity of coal was analyzed. The results show that the maceral components of coal are dominated by vitrinite and inertinite in the study area, and the content of inertinite is below 32%. The vitrinite group has a negative linear correlation with the Langmuir volume, and the inertia composition has a positive linear correlation with it. The cellular structures in the inertinite are the main site of coalbed methane enrichment. The microstructure of coal affects the coal bed methane content and the stage of hydrocarbon generation in coal. This indicates that the microstructure of coal is one of the important factors influencing the adsorption capacity of coal seam..

## 1. Introduction

Coalbed methane is produced from coal and stored in coal seams, it is a kind of unconventional natural gas mainly in an adsorbed state. The main component is methane (CH<sub>4</sub>), which was seemed as a new, clean and safe energy. Coalbed methane development and utilization can help to reduce the effective emissions of methane in coal mines, while improve coal mine production safety and efficiency.

The development of coalbed methane in China began in the late 20th century, and the Qinshui Basin is one of the coalbed methane enrichment regions in the China, due to its unique geological features and resource reservation. The coalbed methane adsorption was studied from different perspectives, such as the adsorption capacity, permeability, crack, stress and the another properties of coal, but the study on the adsorption capacity of the macerals of coal is still ambiguous. The coalbed methane was deposited in the coal seam with adsorption state, dissociate state and dissolved state. For the anthracite, it is mainly composed of the adsorption state gas. Meng Zhaoping<sup>[1,2]</sup> and Bustin<sup>[3]</sup> think that there is a certain relationship between maceral components and adsorption ability. Su Xianbo through the analysis of the maceral-components of coal samples in different areas, it was concluded that the adsorption capacity of the vitrinite was the strongest, the inertia was the second, the exinite was weaker<sup>[4]</sup>. He Xiao-guang analyzes the content and type of maceral-components in coal, and thinks that the maceral-components have a great influence on the adsorption of coalbed methane<sup>[5]</sup>. Some



scholars believed that the maceral of coal is not directly related to the content of coalbed methane. Zhang Feiyan collected geological information on different exploration areas in China, and found that the Langmuir volume and vitrinite content did not change continuously, and the reflectivity of vitrinite was closely related to the Langmuir volume. When the vitrinite reflectivity is large, the inertia group has a higher effect on the adsorption of coalbed methane, and the content of the vitrinite has no effect on the adsorption of coalbed methane<sup>[6]</sup>. We studied the linear relationship between the maceral components of coal and the isothermal adsorption parameters to study its effect on the methane adsorption capacity of coal.

## 2. Experimental samples and methods

### 2.1 Experimental principles and methods for maceral composition

The experimental sample is from coal #3 in Sihe Coalmine of the Shanxi Qinshui Basin, which is a kind of anthracite with high metamorphic and simple structure. According to "Method of preparing coal samples for the coal petrographic analysis (GB/T16772-2008)", the pulverized coal-fired powder were produced as shown in Fig. 1.



Fig. 1 15 samples of coal seam #3 from Sihe Coalmine, China

The pulverized coal sample was placed under the polarized light microscope. In the case of polarized or incomplete orthogonal polarizations, we divide the maceral components and inorganic minerals, and count the volume fraction of maceral components using the statistical method.

(1) The microscope and the computer were turned on, the sample was put on the stage and fixed. The reflected light was turned on, and the lens was focused and corrected to the center. The objective lens was adjusted to 20 times, the eyepiece 110 times. The light source and the visual threshold aperture were adjusted to make a more clear image.

(2) It was ensured that no less than 500 effective measuring points are evenly covered with the whole film. Counting was started from one end of the line, when the line was finished and then changed to a new line. The cross point of the eyepiece should fall at the center of the object to be viewed as a valid point.

(3) When the cross fell on the boundaries of different ingredients, it was started from the upper right quadrant, the apparent threshold fully filled with the maceral components was selected in the clockwise order.

### 2.2 Isothermal adsorption experiment

Through the experiment of isothermal adsorption curve, we can assess the adsorption capacity of coal<sup>[7]</sup>. According to the geological conditions of this study area, the test temperature is 30 °C and the methane concentration is 99.9%. The isothermal adsorption test was carried out under constant

temperature. The experimental pressure range was 0 ~ 7 MPa. Adsorption equilibrium time is not less than 12 hours. Before the isothermal adsorption test, the coal samples were treated with equilibrium moisture.

The experimental steps are as follows:

(1) Experimental pressure point distribution: the equilibrium pressure was not less than 8 MPa, the experimental pressure points were not less than six.

(2) Inflammation: Placed the tested sample in the cylinder, opened the regulating valve and the reference cylinder valve, filled the system with methane, adjust pressure in the reference cylinder to the target pressure.

(3) Data acquisition: when the target pressure and the temperature were stable, opened the acquisition program. Time, pressure, temperature and other related data were collected, and the data were recorded as files.

(4) Adsorption equilibrium time: when the methane adsorption value does not change, it is stable adsorption, the adsorption time were determined.

(5) Repeat (3) to (4) step, Experiment were carried out one by one pressure point until the last pressure point experiment ends.

### 3. Experimental results and analysis

#### 3.1 Observation and analysis of macerals in coal

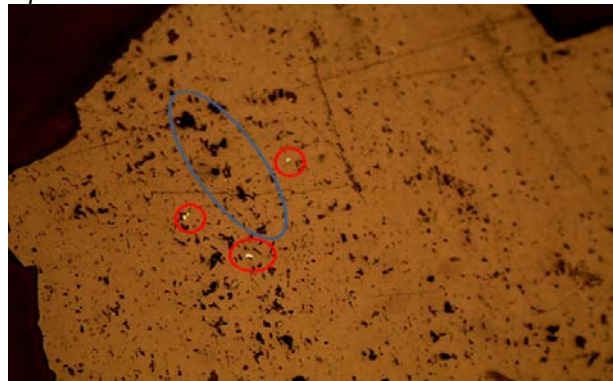


Fig.2 Inertinite and sulfide minerals in coal sample No. 8 from Sihe Coalmine, China

Fig.2 shows inertinite with bright-white or yellow-white under the reflection light. It mainly derived from plant stem, roots, branches of xylem, which were suffered from the carburization<sup>[8,9]</sup>. In Fig.2 the minerals in yellow were the sulfide minerals. It were pale yellow-white with the protruding surface, sometimes it also shown the "sunflower" petal-shaped in the surface under the microscope<sup>[10]</sup>. The clay minerals, as shown in Figure 2, are gray or dark gray under the microscope, the protrusions are not obvious, the surface is particle, and sometimes uneven.

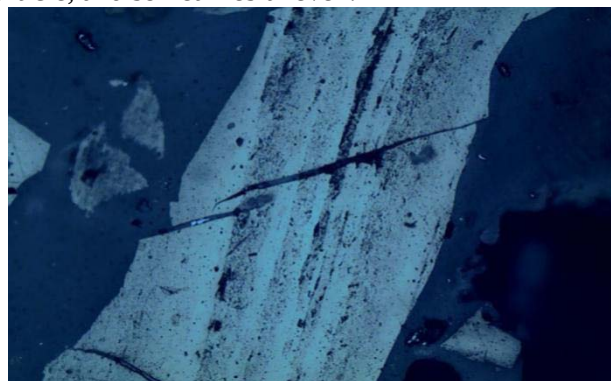


Fig.3 Vitrinite in coal sample No. 8 from Sihe Coalmine, China

The vitrinite was one of the most common and important maceral components of coal. It was formed by the condensation of the roots, stems and leaves of the plant under the condition of water reduction<sup>[8,9]</sup>. Vitrinite is gray to dark gray, and sometimes it is difficult to distinguish between vitrinite and semifusinite in the high rank coal. Fig. 3 shows the sample is in highly metamorphic, and homoeollinite is banded or lenticular appearance with clear outline, sometimes it is perpendicular to the surface of the cracks. One of the reasons why homoeollinite did not show the cellular structure was that it is difficult to distinguish the refractive index and color between the humic gel filling the cell cavity and the gel cell wall<sup>[11]</sup>.

Table.1 Quantitative statistics of maceral components of different coal samples from Sihe Coalmine, China

| Coalsample number | Organic Component (%) |            |          |
|-------------------|-----------------------|------------|----------|
|                   | Vitrinite             | Inertinite | Subtotal |
| 1                 | 73.1                  | 26.9       | 100      |
| 2                 | 82.0                  | 18.0       | 100      |
| 3                 | 87.2                  | 12.8       | 100      |
| 5                 | 81.2                  | 18.8       | 100      |
| 7                 | 88.6                  | 11.4       | 100      |
| 8                 | 86.6                  | 13.4       | 100      |
| 10                | 91.5                  | 8.50       | 100      |
| 11                | 78.3                  | 21.7       | 100      |
| 12                | 85.5                  | 14.5       | 100      |
| 13                | 87.6                  | 12.4       | 100      |
| 14                | 71.1                  | 28.9       | 100      |
| 15                | 68.9                  | 31.1       | 100      |
| 18                | 75.5                  | 24.5       | 100      |

### 3.2 Experimental results and analysis of isothermal adsorption

As shown in Fig.4, The adsorption capacity of samples from coal seam #3 had an obvious difference. It can be seen from Table 1 that the vitrinite content of coal sample No. 13 and No. 14 is different. In Fig.4, coal samples No. 13 and No. 14 shown gradually increasing methane adsorption ability with the increase of pressure. This indicates that the adsorption amount of methane increases with the pressure increase, and this rule still exists in the case of different vitrinite.

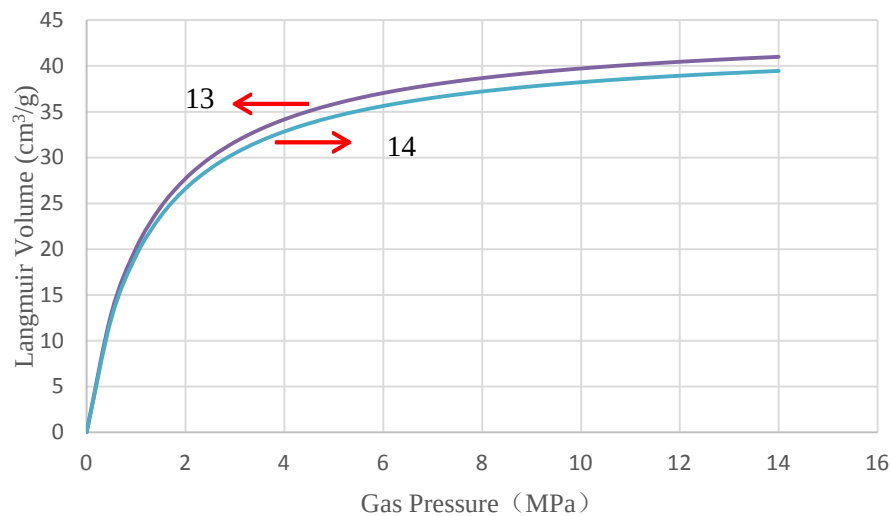


Fig. 4 Isothermal adsorption curves of coal samples 13 and 14

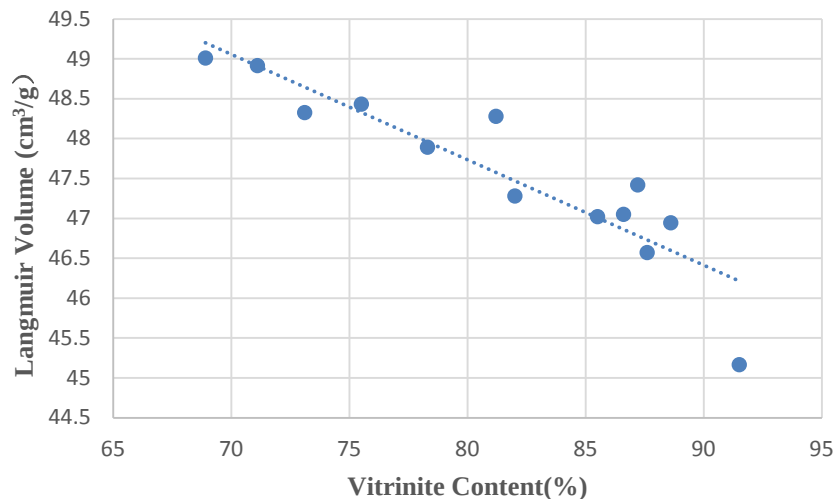


Fig.5 Linear relationship between Langmuir volume and vitrinite content

In Fig. 5, it can be concluded that: with the increase of vitrinite content, the adsorption capacity of coal bed methane decreases gradually, which is negatively correlated. In the vitrinite content of 68.9% ~ 91.5%, the vitrinite content was almost linearly changing with the Langmuir volume, which range change is  $4.21 \text{ cm}^3/\text{g}$ . For the same coal sample, the more the vitrinite content, the weaker the adsorption capacity.

Coalbed methane is mainly adsorbed on coal matrix surface. In the high rank coal in Sihe coal mine, it can be seen from Table 1 that the vitrinite content is higher than the inertia content. Because of the higher metamorphic degree, the non-filled cavities in the inertia were increased. The methane adsorption capacity of coal is negatively correlated with the content of vitrinite, and basically conforms to the linear relationship.

#### 4. Conclusion

Taking the high rank coal #3 from the Shihe Coal Mine in Qinshui Basin as an example, the maceral components of coal were obtained under the microscope. The results shown that the vitrinite content in the coal seam #3 of the Sihe Coal mine is dominant, because it is more than 68%. The average of the inertia is about 16% and the maximum is not more than 32%. The inertia contained a large number of fusinite. While the exinite only accounted for a small proportion of coal, so it is

negligible. The vitrinite group has a negative linear correlation with the Langmuir volume, and the inertinite composition has a positive linear correlation with that. The cellular structures in the inertinite are the main site of coalbed methane enrichment. The maceral content of coal affects the coalbed methane content, and the stage of hydrocarbon generation in coal.

This indicates that the maceral content of coal is one of the important factors influencing the adsorption capacity of coal seam in Sihe coalmine. This study is of great significance to the exploration and development of coalbed methane. Especially, the metamorphic degree of coal is relatively high in China, which is different from that of low and middle rank coal.

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