Analysis Method of the Occurrence Law of Coalbed Gas Based on Gas-Geology Units: A Case Study of the Guhanshan Mine Field, Jiaozuo Coalfield, China

Tianrang Jia, Jiangwei Yan, Xiaolei Liu, Zhendong Feng, Guoying Wei,* and Liu Cao

ABSTRACT: The correct understanding of the occurrence law of coalbed gas (CBG) is the premise of gas disaster prevention, outburst risk prediction, and gas exploitation. The factors affecting gas occurrence in different gas-geology units are different, so the correct division of gas-geology units is the foundation for studying the occurrence law of CBG. In view of this, this paper defined the division principle of gas-geology units. A gas-geology unit is an area with the same gas-geology characteristics. Based on the division of tectonic units, gas-geology units can be divided by integrating the differences of in situ stress, geological factors, and gas distribution of each tectonic unit. Then, taking the Guhanshan mine field in the Jiaozuo coalfield as an example, the analysis method of the occurrence law of CBG based on gas-geology units was expounded. Taking the EW section, NE section, and their extension lines of the Tuanxiang fault as the boundary, the Guhanshan mine field was divided into four tectonic units, and the factors affecting the gas occurrence of each tectonic unit were analyzed. Finally, according to the difference of the bedrock thickness and the CBG distribution in the four tectonic units, combined with the fracture development degree of the coal seam, surrounding rock, and the development degree of deformed coal, the Guhanshan mine field was divided into three gas-geology units, and their occurrence law of CBG was analyzed.

INTRODUCTION

Occurrence law of coalbed gas (CBG) is an important research topic in countries, where energy consumption mainly relies on the coal industry.1,2 A systematic study of the occurrence law of CBG is the foundation and premise of gas disaster prevention, outburst risk prediction, and gas exploitation.3 CBG was formed in coalbeds and stored in coalbeds and their surrounding rock. The formation of CBG was closely related to the geological structure along with the tens of millions to hundreds of millions of year’s evolution of coal-bearing strata. Meanwhile, coal-bearing strata were subjected to depression, uplift, extrusion, and tension in the tectonic movement.4−7 Geologically, CBG is a gaseous geological body, formed in complex geological conditions that may have influenced and restricted its occurrence and distribution.8−10

The current gas occurrence state is the comprehensive action result of the gas formation system, occurrence system, and sealing system, that is, coalbed thickness, coal body structure, coalification degree, burial depth, permeability of surrounding rock, hydrogeological and geological structures, etc.5,11−16 In terms of gas occurrence structure control, numerous scholars have carried out a series of fruitful research referring to geological structure type, structural evolution, tectonic dynamics, tectonic stress field, and the spatial configuration relationship between modern stress and structure.17−27

To sum up, the CBG occurrence is controlled by many factors. The coal beds in China formed early and experienced multistage tectonic movements, resulting under extremely complex gas storage conditions,3,13,28 which is manifested in the fact that the gas occurrence law in different coal fields may be different, even if the gas occurrence law of different coal mines in the same coalfield may also be different, and even the CBG occurrence law of different zones in the same coal mine is also different. Therefore, it is necessary to divide into different units to study the CBG occurrence law of a coal mine. This paper put forward the division principle of gas-geology units and illustrated it taking the Guhanshan mine field as an example. Based on the analysis of regional tectonic evolution and the distribution characteristics of the geological structure in the Guhanshan mine field, the tectonic units of the Guhanshan mine field were divided. Then, combined with the gas-geology data exposed in the Guhanshan mine field, the effects of geological structure, burial depth, bedrock thickness, surrounding rock, coal thickness, and other factors on CBG occurrence were analyzed.
occurrence in different tectonic units were compared and analyzed. Finally, the mine field was divided into three gas-geology units, and their CBG occurrence laws were analyzed.

DIVISION PRINCIPLE OF GAS-GEOLOGY UNITS AND GEOLOGICAL SETTING

Division Principle of Gas-Geology Units. The study area may be divided into several areas according to the difference of CBG occurrence conditions. Each area has the same coal quality and similar geological structure complexity, damage degree of coal seams, deformed coal thickness, etc; the coalbed is basically continuous, and the gas can flow normally along the coalbed, that is, it has the same gas-geology characteristics, and such an area is called a gas-geology unit.

The accuracy of the gas-geology unit division determines the correctness of the understanding of the CBG occurrence law. The correct division of gas-geology units is the foundation for studying the CBG occurrence law. The division principles and precautions of gas-geology units are as follows:

1. The study area may be a coal accumulation area, a coalfield, a mining area, or even a working face. The division of gas-geology units is based on different range of the study area.

2. Geological structures and their evolution control CBG occurrence, so the division of tectonic units is the division basis of gas-geology units. The boundary of gas-geology units should be determined by the main factors controlling CBG occurrence and gas outburst distribution, such as the Tuanxiang fault in this paper.

3. The division of gas-geology units should be determined by integrating the differences of in situ stress, geological factors, and gas distribution. The distribution of in situ stress is mainly controlled by the distribution of geological structure, and because there are few in situ stress test data, this paper discussed the division method of gas-geology units only from the differences of geological factors and gas distribution. Geological factors include coal metamorphic degree, geological structure and its complexity, coalbed thickness, deformed coal thickness, etc. Gas factors include gas content, gas pressure, gas composition, gas emission, gas outburst, gas dynamic phenomenon, etc.

Geological Setting. The Jiaozuo coalfield is generally located at the arc turning part from NNE to EW in the southern section of the Taihang mountain uplift belt (Figure 1). In the late Paleozoic, the Jiaozuo coalfield was a part of the North China Craton. Like other coalfields in North China,
Carboniferous and Permian coal-bearing strata were deposited. After the deposition of coal seams, they mainly experienced multistage tectonic movements such as Indosinian, Yanshanian, and Himalayan, which created the current geological structure pattern. During the Indosinian (T1-J1), the Jiaozuo coalfield experienced N–S compression and formed near EW trending faults (such as Fenghuangling fault) and wide and gentle fold structures. During the Yanshanian (J-K2), the Jiaozuo coalfield formed the NE–NNE trending compression–thrust faults, such as Julishan fault, Mafangquan fault, Genghuang fault, etc. One- or two-layer deformed coal with a thickness of 0.2–0.8 m was widely distributed in the lower or higher part of coal seam B1. During the Himalayan, Eastern China as a whole was in NW tensile stress environment. The original NE trending reverse faults in the Jiaozuo coalfield were reversed to the current normal faults, accompanied by the generation of NW trending faults. The NE trending faults were cut or closed by NW trending faults, which jointly developed and enclosed a series of grabens, horsts, or stepped fault blocks. The Guhanshan mine field is located in the northeast of Jiaozuo coalfield (Figure 1b). The main mining coal seam is coal seam B1, with a stable occurrence, simple structure, and an average thickness of 5.0 m. Coal seam B1 is the coal seam with class III nonspontaneous combustion, and the coal dust is not explosive. The volatile content of coal seam B1 is between 4.93 and 9.37%, an average of 7.10%, which is high-quality anthracite. The original gas contents measured are 2.28 and 9.37%, an average of 7.10%, which is high-quality gas. The Jiaozuo coal seam B1 is the coal seam with a stable occurrence, simple structure, and an average thickness of 5.0 m. Coal seam B1 is the coal seam with class III nonspontaneous combustion, and the coal dust is not explosive. The volatile content of coal seam B1 is between 4.93 and 9.37%, an average of 7.10%, which is high-quality anthracite. The original gas contents measured are 2.28 and 9.37%, an average of 7.10%, which is high-quality gas.

### STRUCTURAL DISTRIBUTION CHARACTERISTICS AND TECTONIC UNIT DIVISION OF MINE FIELD

The Guhanshan mine field is located among the Chizhuang fault, Mafangquan fault, and Jiebei fault (Figure 1b,c). The basic structural outline of the mine field is a monoclinic structure gently dipping to the southeast. The stratum attitude is roughly 40°NE and the dip angle is 12–17°. The faults dominate and small folds appear locally. There are 13 faults with a drop larger than 20 m. Other faults trend NE or NNE except for NW trending the Jiebei fault and Chizhuang fault.

Within the scope of the Guhanshan mine field, NE trending faults are distributed in strips. In the northern part of the mine field, the thickness of the overlying strata near Taihang Mountain is small, and the faults are staggered from the Guanzhuang fault to the Xiaofengao fault to the Xiangyangcun fault. In the central part of the mine field, the faults are composed of Tuanxiang fault and faults in the NE extension direction of the Tuanxiang fault, such as DF5, DF6, DF18, DF21, etc. In the south of the mine field, the Mafangquan fault at the mine field boundary is dominant; the fault throw of the NE trending faults is generally small, less than 200 m. The clamping area between the Mafangquan fault and Tuanxiang fault formed a small graben.

From the perspective of the structural distribution characteristics, based on the EW section of the Tuanxiang fault and its extension line, the Guhanshan mine field can be divided into two east–west blocks. Based on the NE section of the Tuanxiang fault and its extension line, the Guhanshan mine field can be divided into two north–south blocks so that the whole mine field can be divided into four tectonic units (Figure 2). Overall, tectonic unit 1 is a graben structure, tectonic unit 2 is a fault step structure, and tectonic units 3 and 4 are monoclinic structures with a relatively simple structure.

### RESULTS AND DISCUSSION

**Discussion of Factors Influencing on CBG Occurrence. Influence of Geological Structure on CBG Occurrence.** All of the faults exposed in the Guhanshan mine field are normal faults, most of which strike NE and EW, with dip angles ranging from 30 to 75°. The vertical joints of rocks and coal seam B1 near the faults are developed, which is conducive to gas escape. For example, near faults, especially large faults, the gas content generally decreases. In tectonic unit 1, near the intersection of the Jiebei fault and Mafangquan fault, the gas content is relatively low. In tectonic unit 2, the gas content of boreholes 22-1, 23-4, and 25-2 near the Guanzhuang fault zone is lower than 8 m³/t, which is significantly lower than that of other boreholes under the same conditions. At the junction of tectonic units 1 and 2, the gas content changes regularly due to the influence of the Tuanxiang fault. At a depth of ~600 m, the Tuanxiang fault extends along the coal seam tendency with a
drop of 150–200 m, which is conducive to the migration of CBG from deep to shallow. A gas release zone with a width of about 800 m was formed on both sides of the fault, and the gas content is less than 15 m$^3$/t. At a depth of ~600 m, the fault trend turns to NE, which is consistent with the trend of coal seams. The fault drop gradually decreases until it is pinched out, which is conducive to gas accumulation. A high gas zone with a width of about 200 m was formed on both sides of the fault, and the gas content is more than 20 m$^3$/t. As can be seen from the geological exploration borehole profiles on both sides of the Chizhuang fault (Figure 3), coal seam B$_1$ passing through the Chizhuang fault is connected with the Cenozoic loose layer with high permeability, which is conducive to gas escape, which is one of the important reasons for the overall low gas content of tectonic units 3 and 4.
Influence of Burial Depth on CBG Occurrence. The burial depth of coal seam B1 gradually increases from NW to SE (Figure 2), which is consistent with the monoclinic structure with high NW and low SE. The burial depth in tectonic units 1 and 4 is large, more than 800 m. The gas content increases with the burial depth (Figure 4). In tectonic units 1 and 2, the relationship between the gas content and the burial depth is relatively discrete, and the overall trend is consistent. In tectonic unit 3, the linear relationship between the gas content and the burial depth is better. In tectonic unit 4, the relationship between the gas content and the burial depth is also discrete. Under the same burial depth, the gas content in tectonic unit 3 is the lowest, followed by tectonic unit 4.

Influence of Bedrock Thickness on CBG Occurrence. The Cenozoic strata are mainly a loess layer and loose gravel layer, with poor cementation, large porosity, and good connectivity, which is easy to escape gas. Bedrock thickness overlying coal seam B1 is the burial depth of the coal seam minus the thickness of Cenozoic loess and loose gravel layers. According to the histograms of geological exploration boreholes in the Guhanshan mine field, the contour of bedrock thickness is drawn, as shown in Figure 5. The bedrock thickness in the mine field varies greatly, with the thinnest less than 200 m and the thickest more than 600 m. In tectonic unit 1, the bedrock thickness is generally more than 400 m, which is the thickest area of bedrock in the mine field. In tectonic unit 2, the bedrock thickness is mostly less than 400 m. In tectonic unit 3, the bedrock thickness is mostly less than 300 m, influenced by the Chizhuang fault; there is a thin bedrock zone with a bedrock thickness of less than 200 m. In tectonic unit 4, the bedrock thickness is 300–400 m. Under the same burial depth, the bedrock thickness of tectonic unit 1 is larger than that of tectonic unit 4, and the bedrock thickness of tectonic unit 2 is greater than that of tectonic unit 3.

The gas content in different tectonic units varies with the bedrock thickness (Figure 6). In tectonic unit 1, the gas content is mainly influenced by the Tuanxiang fault and Mafangquan fault; although the bedrock thickness is large, the gas content does not increase significantly. In tectonic units 2 and 4, the gas content increases with the increase of bedrock thickness and the increasing gradients are basically the same. Under the same bedrock thickness, the gas content of tectonic unit 3 is significantly less than that of tectonic units 2 and 4.

Influence of Surrounding Rock on CBG Occurrence. The siltstone in the roof of coal seam B1 often contains coal line or argillaceous matter in the Guhanshan mine field, which may be conducive to gas preservation. The ratio of the sum of mudstone and siltstone thickness to the strata thickness within 30 m of the coal seam roof is defined as MSSR. According to the histograms of geological exploration boreholes, the contour of the MSSR is drawn, as shown in Figure 7. MSSR in each gas-geology unit has little difference, generally 0.5–0.8, that is, there is little difference in the overall thickness of mudstone and siltstone. With the increase of MSSR, the gas content increases as a whole (Figure 8), which indicates that both
Influence of Coal Thickness on CBG Occurrence. The coal seam occurrence in the Guhanshan mine field is relatively stable, with a thickness of 4.0–6.0 m and there is little difference among tectonic units (Figure 9). As can be seen from the relationship between the gas content and coal thickness (Figure 10), the correlation between the gas content and coal thickness in the mine field is poor.

Influence of Coal Seams and Roof Cracks on CBG Occurrence. The fractures of surrounding rock and coal seams have a certain impact on gas preservation. Fractures refer to coal cleats and joints in this paper. In tectonic unit 1, the coal seam fractures are relatively underdeveloped but relatively developed in some areas (Figure 11a). There are no large-area filling phenomena of calcite and other minerals, which also reflect that the coal body fractures of the working face are not very developed from the side. In tectonic unit 2, the fracture development density in the middle and upper part of coal seam
B1 is large, up to 10 pieces/cm (Figure 11b), and the fracture development density in the lower part is only 1.5 pieces/cm. At the same time, the fracture length is different, mostly distributed at nearly 50 cm, and there are almost no large fractures penetrating coal and rock layers. There are few intersections between fractures, mainly a single group of parallel joints, which cannot form an effective fracture network. A large number of X-shaped shear joints can be seen in this area (Figure 11c). Overall, except for some large joints, the fracture width is generally small, and most of them are filled with calcite (Figure 11d), resulting in low permeability of the coal seam. In tectonic unit 3, fractures are developed, with an average density of 4/10 cm, but the distribution of fractures is uneven (Figure 11e). At the same time, there are also great differences in the scale of fractures. Fractures ranging from centimeters to meters can be seen in the coal seam, and some large fractures can even run through several coal and rock layers to the roof of the coal seam (Figure 11f). The fractures in this area are mainly large- and medium-sized fractures with a large dip angle, supplemented by small fractures (Figure

Table 1. Statistics of Deformed Coal Thickness in the Guhanshan Mine Field

| working face | thickness of primary structure coal at the top (m) | thickness of deformed coal (m) | thickness of primary structure coal t (m) | thickness of deformed coal at the bottom (m) | total thickness of deformed coal (m) | total thickness of the coal seam (m) | tectonic unit |
|--------------|---------------------------------------------|-------------------------------|------------------------------------------|-------------------------------------------|----------------------------------|-----------------------------------|---------------|
| 1416         | 0.6                                        | 0.5                           | 4.6                                      | 0.3                                       | 0.8                              | 6.0                                | tectonic unit 1 |
| 1418         | 0.6                                        | 0.3                           | 4.5                                      | 0.3                                       | 0.6                              | 5.7                                | tectonic unit 2 |
| 1603         | 0.6                                        | 0.2                           | 5.6                                      | 0.3                                       | 0.5                              | 6.7                                | tectonic unit 2 |
| 1401         | 0.6                                        | 0.3                           | 4.1                                      | 0.5                                       | 0.8                              | 5.5                                | tectonic unit 2 |
| 1402         | 0.6                                        | 0.4                           | 4.5                                      | 0.5                                       | 0.9                              | 6.0                                | tectonic unit 2 |
| 1403         | 0.6                                        | 0.2                           | 4.1                                      | 0.5                                       | 0.7                              | 5.4                                | tectonic unit 2 |
| 1404         | 0.6                                        | 0.4                           | 4.3                                      | 0.6                                       | 1.0                              | 5.9                                | tectonic unit 2 |
| 1410         | 0.6                                        | 0.3                           | 4.3                                      | 0.6                                       | 0.9                              | 5.8                                | tectonic unit 2 |
| 1411         | 0.5                                        | 0.3                           | 4.1                                      | 0.6                                       | 0.9                              | 5.5                                | tectonic unit 2 |
| 1413         | 0.4                                        | 0.3                           | 4.1                                      | 0.5                                       | 0.8                              | 5.3                                | tectonic unit 2 |
| 1415         | 0.6                                        | 0.4                           | 4.5                                      | 0.6                                       | 1.2                              | 5.7                                | tectonic unit 2 |
| 1412         | 0.6                                        | 0.3                           | 4.5                                      | 0.8                                       | 1.1                              | 6.2                                | tectonic unit 2 |
| 1414         | 0.6                                        | 0.4                           | 4.5                                      | 0.6                                       | 1.0                              | 6.1                                | tectonic unit 2 |
| 1505         | 4.8                                        | 0.5                           | 4.6                                      | 0.5                                       | 4.5                              | 5.3                                | tectonic unit 3 |
| 1507         | 4.6                                        | 0.6                           | 4.9                                      | 0.5                                       | 4.8                              | 5.2                                | tectonic unit 3 |
| 1509         | 4.9                                        | 0.5                           | 4.7                                      | 0.5                                       | 4.8                              | 5.3                                | tectonic unit 3 |
| 1702         | 4.7                                        | 0.5                           | 4.8                                      | 0.5                                       | 4.8                              | 5.2                                | tectonic unit 3 |
| 1704         | 4.8                                        | 0.5                           | 4.8                                      | 0.5                                       | 4.8                              | 5.3                                | tectonic unit 3 |
| 1701         | 3.7                                        | 0.5                           | 4.8                                      | 0.5                                       | 4.8                              | 4.2                                | tectonic unit 3 |

Figure 11. Observation diagram of the underground coal seam fracture in the Guhanshan mine field observation location: (a) 1606 working face; (b–d) 14171 working face; (e–h) 15091 working face; (i) 15072 working face. (b–h) Reproduced with permission from ref (32). Copyright 2021 Henan Polytechnic University.
The fractures in the roof and top of the coal seam are particularly developed, and most of them were filled with calcite (Figure 11i). Tectonic unit 4 has no roadway engineering, so it is impossible to observe the coal seam and its roof fractures.

In addition, in the process of ground grouting reinforcement for water disaster control, the grouting fluid of the grouting holes in tectonic units 1 and 2 returned, and the grouting fluid in tectonic unit 3 did not return. For example, the grouting fluid in grouting hole 9 was lost at 15 m from the coal roof, and the leakage was 40 m³/h. The loss of grouting fluid indicates that the fractures are relatively developed. Therefore, the roof fractures of coal seams in tectonic unit 3 are more developed than those in tectonic units 1 and 2.

To sum up, the fractures of coal seams and roof in tectonic unit 3 are more developed than those in tectonic units 1 and 2, which may be one of the reasons why the gas content in tectonic unit 3 is lower than that in tectonic units 1 and 2 under the same burial depth.

Influence of Deformed Coal on CBG Occurrence. In the area where deformed coal is developed, the coal structure is broken and the coal permeability is poor, which is conducive to gas preservation. From the coal structure exposed by mining in the mine field (Table 1), two layers of deformed coal are generally developed in tectonic units 1 and 2, which are located at 0.4–0.6 m near the roof and at the bottom of the coal seam, respectively. The thickness of deformed coal in tectonic units 1 and 2 accounts for 7–13 and 13–21% of the total coal thickness, respectively. Deformed coal in tectonic unit 3 is located at the bottom of the coal seam and accounts for 9–12% of the total coal thickness.

Deformed coal is widely developed at the top of the coal seam in tectonic units 1 and 2, and the coal body has poor permeability, which is conducive to gas preservation, which may also be one of the reasons for the high gas content in the west of the mine field.

Gas-Geology Units of the Mine Field and Their CBG Occurrence Law. Division Basis of Gas-Geology Units. Difference in Distribution of Geological Factors. According to the geological factors influencing on the CBG occurrence analyzed above, the geological factors such as burial depth, coal thickness, and surrounding rock have little difference in the different tectonic units (Figures 2, 7, and 9). The bedrock thickness, structural distribution and development degree, fractures of coal seams and surrounding rock, and deformed coal development degree are obviously different in different tectonic units.

Bedrock Thickness. The bedrock thickness varies with burial depth in different tectonic units, as shown in Figure 12. Under the same burial depth, the bedrock thickness in tectonic units 1 and 2 is significantly larger than that of tectonic units 3 and 4, especially when the burial depth is 400 m, the difference is even larger, with a difference of 200–300 m. Although tectonic units 1 and 2 are located in the hanging wall and footwall of the northeast section of the Tuanxiang fault, respectively, the difference of bedrock thickness is small under the same burial depth, and the bedrock thickness increases significantly and tends to be consistent with the burial depth from shallow to deep. The bedrock thickness in tectonic unit 3 is the thinnest. The burial depth ranges from 162 to 861 m, and most of the bedrock thickness is less than 200 m. The burial depth of tectonic unit 4 is 600–1000 m, and the bedrock thickness is 200–400 m. Overall, it tends to increase with the increase of burial depth.

Structural Distribution and Development Degree. The structures in the mine field are dominated by normal faults, with three groups of high-angle normal faults in NE direction, NW direction, and near EW direction. On the whole, it is bounded by the near EW section and extension line direction of the Tuanxiang fault (Figure 2). The fault development degree in the west (tectonic units 1 and 2) is high, while the fault development density in the east (tectonic units 3 and 4) is low. That is, the west may face greater destructive force and
| Gas-geology unit | Tectonic units | Fault development density | Bedrock thickness characteristics | Development characteristics of deformed coal | Gas distribution characteristics | Coal rock fissure characteristics | Main controlling factors | Gas geology characteristics |
|------------------|---------------|--------------------------|----------------------------------|-----------------------------------------------|---------------------------------|-------------------------------|--------------------------|---------------------------|
| I                | 1 and 2       | Large, mainly including boundary faults such as Jiulishan fault, Fanghuang fault, and Maofangqiang fault, as well as Tuanni fault, Guanhuang fault, and Xiaofengqiao fault. | Under the same burial depth, the bedrock thickness is the largest, which is obvious with the increase of burial depth. | Two layers of deformed coal with a thickness of about 0.4–0.8 m are generally developed at a certain distance from the top and bottom of the coal seam. | Under the same burial depth, the gas content is the highest, gas outburst is the most serious. | Developed | Bedrock thickness | Thick bedrock, strong compression, low permeability, and high gas pressure. |
| II               | Unit 3        | Low, and the boundary of the tectonic unit is developed with the NE fault zone composed of Chizhuang fault, DF5, DF6, DF18, and DF21, as well as Nansu fault and Xiangyangcun fault in the shallow part of the mine field. | Under the same burial depth, the bedrock thickness is the thinnest, which is less than 200 m, and the bedrock thickness changes little. | Under the same burial depth and the same bedrock thickness, the gas content and gas pressure are the lowest. | Under the same burial depth and the same bedrock thickness, the gas content is lower than that of gas-geology unit I and much higher than that of gas-geology unit II. | Developed | Bedrock thickness | Thin bedrock, high permeability, low damage, and low gas pressure. |
| III              | Unit 4        | Low, and the boundary of tectonic unit 4 is developed with the northeast fault zone composed of DF9, DF18, and DF21, as well as the EW section of the Tuanni fault. | Bedrock thickness is relatively thin. Under the same burial depth, it is less than gas-geology unit I and the overall thickness is larger than gas-geology unit II. | No roadway works | Under the same burial depth, the gas content is lower than that of gas-geology unit I and much higher than that of gas-geology unit II. Under the same bedrock thickness, it is equivalent to gas-geology unit I and much higher than gas-geology unit II. | Developed | Bedrock thickness | Relatively thick bedrock, low permeability, and high gas pressure. |

**Table 2. Gas-Geology Units and CBG Occurrence Characteristics in the Guhanshan Mine Field**
The occurrence law of CBG based on gas-geology units. The major conclusions are as follows.

1. The definition and division principle of gas-geology units were clarified. A gas-geology unit is an area with the same gas-geology characteristics. Based on the division of tectonic units, gas-geology units can be divided by integrating the differences of in situ stress, geological factors, and gas distribution of each tectonic unit.

2. The Tuaxiang fault is the main control structure of the mine field. Taking the EW section and the NE section of the Tuaxiang fault and their extension line as the boundary, the Guhanshan mine field was divided into four tectonic units. Tectonic unit 1 is a graben structure, tectonic unit 2 is a fault step structure, and tectonic units 3 and 4 are monoclinic structures with a relatively simple structure.

3. Controlled by the Tuaxiang fault and Chizhuang fault, the bedrock thickness overlying the coal seam in the mine field has the overall distribution characteristics, that is, thick in the west and thin in the east, thin in the shallow and thick in the deep, which is one of the main reasons for the high gas in the west, low gas in the east, low gas in the shallow, and high gas in the deep.

4. According to the different bedrock thickness and gas distribution in different tectonic units, combined with the fracture development degree in the coal seam and surrounding rock and the development degree of deformed coal, the Guhanshan mine field was divided into three gas-geology units, and the CBG occurrence law of the three gas-geology units was analyzed.

5. This analysis method of the occurrence law of CBG can be applied to other mine fields, but it is necessary to divide the tectonic units in combination with the gas-geology conditions of the mine fields and reveal the differences of each tectonic unit in in situ stress, geological factors, and gas distribution.

**AUTHOR INFORMATION**

**Corresponding Author**
Guoying Wei — School of Safety Science and Engineering, Henan Polytechnic University, Jiaozuo, Henan 454003, China; Collaborative Innovation Center of Coal Work Safety and Clean High Efficiency Utilization, Jiaozuo, Henan 454003, China; Email: wgy@hpu.edu.cn

**Authors**
Tianrang Jia — School of Safety Science and Engineering, Henan Polytechnic University, Jiaozuo, Henan 454003, China; Collaborative Innovation Center of Coal Work Safety and Clean High Efficiency Utilization, Jiaozuo, Henan 454003, China; Collaborative Innovation Center of Coal Work Safety and Clean High Efficiency Utilization, Jiaozuo, Henan 454003, China
Jiangwei Yan — School of Safety Science and Engineering, Henan Polytechnic University, Jiaozuo, Henan 454003, China; Collaborative Innovation Center of Coal Work Safety and Clean High Efficiency Utilization, Jiaozuo, Henan 454003, China
Xiaolei Liu — School of Safety Science and Engineering, Henan Polytechnic University, Jiaozuo, Henan 454003, China; Collaborative Innovation Center of Coal Work Safety and Clean High Efficiency Utilization, Jiaozuo, Henan 454003, China

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