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Features of gas geology and its main controlling factors in Pingxiang Mining Area, Jiangxi Province *

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Abstract Pingxiang Mining Area in Jiangxi Province is one of the major coal-producing areas and is prone to serious coal and gas outburst, therefore, it is of significance to research on gas geological features and its controlling factors. Based on the analysis of gas data collected from geological exploration and coal mining, the research reveals that the features of gas geology vary significantly between west part and east part of Pingxiang Mining Area, and it is characterized by high gas mines with serious coal and gas outburst in the west part and low gas mines with no coal and gas outburst in the east part. The main controlling factors to gas geology are discussed, and the great difference of gas geology between west part and east part is the result of comprehensive effect by geological factors. Concerning the gas generation, the coal rank in the west part is higher than that in the east part, which is favorable to generate more gas in the west part than in the east part. Concerning the gas preservation, the structures are characterized by gliding nappe in the west part and by tectonic window in the east part, the surrounding rocks are characterized by poor permeability in the west part and comparatively good permeability in the east part, and the characteristics of coal rank and coal body structure are favorable to gas preservation in the west part and favorable to gas emission in the east part.

Keywords Pingxiang Mining Area, coal and gas outburst, gliding nappe, coal rank, surrounding rock

1 General geology of Pingxiang Mining Area

Pingxiang Mining Area is located in the central part of Pingxiang City of Jiangxi Province. The east-to-west length is about 25 km, while the north-to-south width is about 10 km, and the coal-bearing area is about 250 km^2 (Fig.1). Pingxiang Mining Area is one of the major coal-producing areas in Jiangxi Province (Tan et al., 2009). From west to east, there are five major coal mines in Pingxiang Mining Area named Juyuan Coal Mine, Qingshan Coal Mine, Baiyuan Coal Mine, Anyuan Coal Mine, and Gaokeng Coal Mine. Pingxiang Mining Area is very serious in coal and gas outburst (Xie et al., 2001; Chen and Wang, 2009; Zhang et al., 2010). Therefore, it is of significance to research on gas geological features and its controlling factors.

The coal seams in Anyuan Formation are the mining objects in Pingxiang Mining Area. Anyuan Formation is unconformable above Maokou Formation, Longtan Formation of the Permian, or Daye Formation of the Triassic. From bottom to top, Anyuan Formation (T_3a) is subdivided into Zijiachong Stage (T_3a^1), Sanjiachong Stage (T_3a^2), and Sanqiutian Stage (T_3a^3). Within the Anyuan Formation, Zijiachong Stage is well developed and includes several

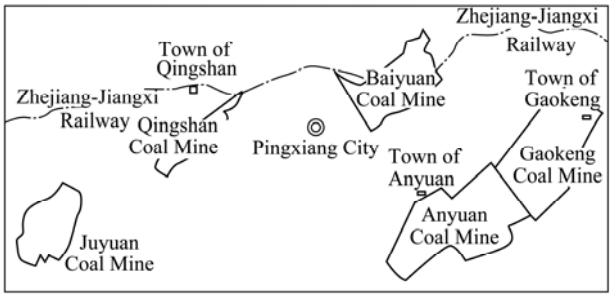

Fig.1 Distribution of five major coal mines in Pingxiang Mining Area

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minable coal seams (Table 1), and the thickness of this stage ranges from 64 to 289 m, averaging 160 m. Sanjiachong Stage is the sediment usually with no coal seam, and the thickness of this stage ranges from 256 to 347 m, averaging 288 m. Sanqiutian Stage is the sediment with no minable coal seams, and the thickness of this stage ranges from 193 to 488 m, averaging 347 m.

Table 1 Statistics of coal seams of Zijiachong Stage of Anyuan Formation in Pingxiang Mining Area

Coal mine	Number of coal seams	Total thickness of coal seam (m)	Number of minable coal seams	Total thickness of minable coal seam (m)	Coal-bearing ratio (%)
Gaokeng	12	14.92	5	7.27	3.50
Anyuan	4	7.84	3	5.91	3.92
Baiyuan	5	22.67	2	5.58	4.30
Qingshan	12	28.59	9	20.51	4.30
Juyuan	11	31.74	8	14.11	4.02

2 Features of gas geology

The features of gas geology are significantly different between west part and east part in Pingxiang Mining Area, and the features are introduced respectively.

2.1 Gas geology's features in the west part

There are five representative coal mines in the west part of Pingxiang Mining Area. Juyuan Coal Mine and Qingshan Coal Mine are two state-owned coal enterprises, while Shangguanling Coal Mine, Jiaobao Coal Mine, and Santian Coal Mine are three local state-owned coal enterprises. The gas geology of these coal mines is featured by high gas coal mine with coal and gas outburst. The gas information is briefly given here.

For Juyuan Coal Mine, the information from geological exploration reveals that nine gas contents are high, ranging from 6.07 to 12.70 m^3/t, averaging 9.11 m^3/t corresponding to the buried depth from 171 to 792 m. The information from Identification of Classification of Gaseous Mine reveals that the relative gas emission rate of coal mine is 49.05 m^3/t and the absolute gas emission rate is 23.08 m^3/min, and Juyuan Coal Mine is a high gas mine with coal and gas outburst. Until present, there are 21 coal and gas outbursts happened, the mean value of outburst coal is 57.7 t, the maximum value of outburst coal is 420 t, and the maximum value of outburst gas is 8 280 m^3.

For Qingshan Coal Mine, the information from geological exploration reveals that 9 values of gas contents are high, ranging from 7.33 to 18.31 m^3/t, averaging 13.32 m^3/t corresponding to the buried depth from 213 to 886 m. Gas contents from the testing during the period of coal mining are also high, ranging from 7.82 to 24.63 m^3/t, averaging 13.00 m^3/t. The information from Identification of Classification of Gaseous Mine reveals that the relative gas emission rate of coal mine is 18.65 m^3/t and the absolute gas emission rate is 20.19 m^3/min, and Qingshan Coal Mine is a high gas mine with coal and gas outburst. Until the present, there are 42 coal and gas outbursts happened, the mean value of outburst coal is 43.6 t, the maximum value of outburst coal is 426 t, and the maximum value of outburst gas is 39 200 m^3.

For Shangguanling Coal Mine, the information from Identification of Classification of Gaseous Mine reveals that the relative gas emission rate of coal mine is 12.33 m^3/t and the absolute gas emission rate is 1.84 m^3/min, and Shangguanling Coal Mine is a high gas mine.

For Jiaobao Coal Mine, the information from the Identification of Classification of Gaseous Mines reveals that the relative gas emission rate of coal mine is 19.44 m^3/t and the absolute gas emission rate is 1.89 m^3/min, and Jiaobao Coal Mine is a high gas mine.

For Santian Coal Mine, the relative gas emission rate of coal mine is 13.64 m^3/t. There are eight coal and gas outbursts happened and the maximum value of outburst coal is 14 t, and Santian Coal Mine is a high gas mine with coal and gas outburst.

2.2 Gas geology's features in the east part

There are eight representative coal mines in the east part of Pingxiang Mining Area. Baiyuan Coal Mine, Anyuan Coal Mine, and Gaokeng Coal Mine are three state-owned coal enterprises, while Wangkeng, Wupi, Hongqi, Panjiachong, and Yuejin coal mines are five local state-owned coal enterprises. The gas geology of these coal mines is featured by low gas coal mine with no coal and gas outburst. The gas information is briefly given here.

The gas contents from the testing during the period of coal mining are very low (Table 2). The information from Identification of Classification of Gaseous Mine reveals that all these eight coal mines are low gas mines (Table 3).

3 Discussion

From the above, in Pingxiang Mining Area, there are significant differences between high gas area of

west part and low gas area of east part. The main controlling factors of gas geology are discussed here.

Table 2 Gas contents of major coal mines in the east part of Pingxiang Mining Area

Coal mine	Amount of testing	Buried depth (m)	Gas content (m^3/t)		
			Min	Max	Mean
Baiyuan	47	282–682	0.001 4	0.018 0	0.012 4
Anyuan	43	142–461	0.43	4.76	1.81
Gaokeng	34	425–661	0.92	3.01	1.98

Table 3 Results of classification identification of gaseous mines in the east part of Pingxiang Mining Area

Coal mine	Absolute gas emission rate (m^3/min)	Relative gas emission rate (m^3/t)	Classification of gaseous mine
Baiyuan	0.09	0.17	Low gas mine
Anyuan	3.60	5.60	Low gas mine
Gaokeng	1.74	0.98	Low gas mine
Wupi	1.68	6.53	Low gas mine
Yuejin	1.25	8.37	Low gas mine
Wangkeng	8.43	2.46	Low gas mine
Hongqi	0.80	8.25	Low gas mine
Panjiachong	1.08	8.41	Low gas mine

3.1 About the gas generation

In the west part, the coal ranks are high, and most of them are high-rank bituminous or anthracite, slim coal or meager coal for Juyuan Coal Mine, meager coal for Shangguanling Coal Mine, and anthracite for Qingshan Coal Mine, Jiaobao Coal Mine, and Santian Coal Mine. But in the east part, the coal ranks are comparatively low, and most of them are medium-rank bituminous, coking coal for Baiyuan Coal Mine and Wupi Coal Mine, 1/3 coking coal for Wangkeng Coal Mine, Hongqi Coal Mine, and Panjiachong Coal Mine, fat coal or 1/3 coking coal for Anyuan Coal Mine and Gaokeng Coal Mine, and fat coal for Yuejin Coal Mine.

The metamorphism degree of coal and gas storage is closely related. The higher the metamorphism degree of coal is, the more the coal's gas productivity is (Zhang, 2009). Therefore, from the angle of gas generation, the higher metamorphism degree of coal in the west part than that in the east part means more gas produced for coal in the west part than that in the east part.

3.2 About the gas preservation

3.2.1 Factor of structure

During Middle Proterozoic to Early Paleozoic, Jiangxi Province is separated by Yangtze Plate and South China Plate. Between these two plates, there is a combination belt, named Pingxiang-Leping Depression. Yangtze Plate, Pingxiang-Leping Depression, and South China Plate are three first-level tectonic units in the northern, middle, and southern parts of Jiangxi Province (Jiangxi Provincial Bureau of Geology and Mineral Resources, 1984; Liu et al., 2004). Pingxiang Mining Area is located in the north side of Wugong Uplift (Fig.2).

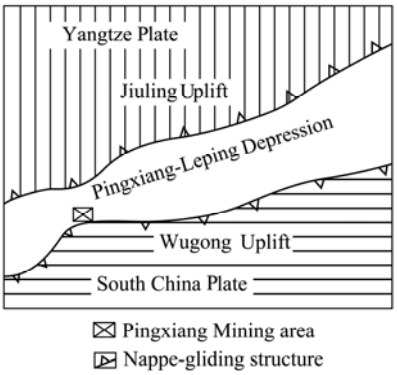

Fig.2 Tectonic location of Pingxiang Mining Area (modified according to Liu et al., 2004)

The gravitational sliding structure is well developed in Pingxiang Mining Area (Hu, 2002; Liu, 2003). During Yanshan period, due to the strong uplift of the Wugong Uplift and the effect of gravity balance, some gravitational glidings are formed in north side of the mountains of Wugong Uplift. Fig.3 is the correlation section between Anyuan gliding block and Gaokeng gliding block. From top to bottom, the strata of the gliding block consist of the following: the Cretaceous is unconformable above the Anyuan coal-bearing strata, Anyuan coal-bearing strata is unconformable above the Maokou Formation, the bottom of Maokou Formation is gravitational gliding fault, and Anyuan coal-bearing strata is under the gliding block.

From the angle of geological structure, the coal-bearing strata in the area of Qingshan Coal Mine and Juyuan Coal Mine are under the gliding nappe. The Maokou Formation is slid over the Anyuan Formation, so the overlying rock's thickness of coal-bearing strata is increased, which cause the gas in coal seams to be well preserved (Fig.4). Meanwhile, Gaokeng Coal Mine, Anyuan Coal Mine, and Baiyuan Coal Mine are in the area of tectonic window, and the coal-bearing strata within the tectonic window are exposed to ground for a long time to be favorable to gas migration and emission. Thus, the west part of Pingxiang Mining Area is high gas area with serious coal and gas outburst, while the east part is low gas area.

Also, in the west part of Pingxiang Mining Area, the small structures at Qingshan Coal Mine and Juyuan

Coal Mine are well developed, and the syncline and anticline structures are all incomplete and very close, which is favorable to gas preservation. Meanwhile, in the east part, the structures are comparatively simple, and the synclines are wide and gentle, which is favorable to gas migration and emission.

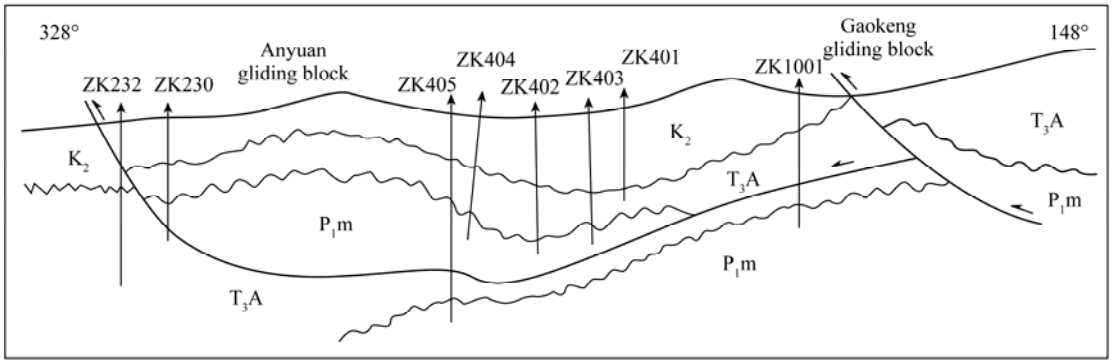

Fig.3 Correlation section between Anyuan gliding block and Gaokeng gliding block (according to Liu et al., 2003)

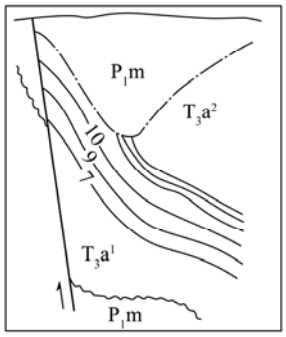

Fig.4 Section of gliding nappe structure at Juyuan Coal Mine

3.2.2 Factor of surrounding rock of coal seam

Some researches are reported concerning the sedimentary features in Pingxiang Mining Area (Yan and Wu, 1995; Yan et al., 1995; Xie et al., 2001; Chen and Peng, 2005). For Qingshan Coal Mine, the coal seams of Zijiachong Stage have good conditions to prevent gas migration. The ratio of sandstone to mudstone within 50 m of roof and floor is lower, and the carbonaceous mudstone and mudstone in roof and floor are thick and tight, so the permeability of the roof and floor is low, which provides the favorable conditions for gas storage. Also, for Juyuan Coal Mine, the roof rock of the main coal-bearing section is 350 m mud-cement siltstone, and the floor rock is 60 m tight mudstone, which is favorable to gas preservation.

On the contrary, the area of Anyuan Coal Mine and Gaokeng Coal Mine is close to the supply area of terrigenous clastic of Wugong Uplift. The coarse clastic in coal-bearing strata, including sandstone and conglomerate, are more, so the permeability of coal-bearing strata is better than that at Qingshan Coal Mine and Juyuan Coal Mine. About Baiyuan Coal Mine, the coal-bearing strata of Triassic are directly contacted with the Cretaceous red layer, and the entire Jurassic strata are missed, which shows that a large amount of gas is released for a long weathering and erosion period before the sediment of Cretaceous red layer.

3.2.3 Factor of coal quality

The metamorphic degree of coal has considerable influence on coal's gas adsorption capacity. The coal's gas adsorption capacity increases from medium-rank bituminous to anthracite (Zhang, 2009). The statistics based on the data from more than 160 mining area in China (Qin et al., 1999) reveal the enveloping line relationship between the coal rank and gas content in coal reservoir, that is, with the increase coal rank from brown coal to the early stage of anthracite, the maximum gas content of coal seam increases, and the area with high gas content corresponds to the area with high rank coal. However, with the increase coal rank from middle stage to later stage of anthracite, the methane adsorption capacity of coal seam decreases, and correspondingly, the maximum gas content of coal seam sharply decreases. Therefore, concerning the gas adsorption capacity, in Pingxiang Mining Area, the coal rank is higher in the west part than that in the east part, which means that the coal in the west part may have adsorpted more gas than that in the east part.

In the west part of Pingxiang Mining Area, many of the coal body structures are destroyed and tectonic coals are widely distributed. The coals are soft and fragile, most of them are mylonitic coal and granulated coal, and few of them are cataclastic coals. The test of 22 samples at Qingshan Coal Mine reveals that the consistent coefficient of coal (f value) is very small, ranging from 0.130 to 0.283, averaging 0.204, and index of coal's initial speed of diffusion (ΔP) is high, ranging from 13 to 22, averaging 16.63. The test of 13 samples at Juyuan Coal Mine reveals that f value ranges from 0.160 to 0.460, averaging 0.251, and ΔP ranges from 9 to 19, averaging 13.62. Therefore, the characteristic of coal body structure is favorable to the

preservation of gas and conducive to the coal and gas outburst (The State Administration of Work Safety, 2009).

4 Conclusions

(1) The features of gas geology vary significantly between the west part and the east part of Pingxiang Mining Area, and it is characterized by high gas mines with serious coal and gas outburst in the west part and low gas mines with no coal and gas outburst in the east part.

(2) The great difference of gas geology between the west part and the east part is the result of comprehensive effect by geological factors. Concerning the gas generation, the coal rank in the west part is higher than that in the east part, which is favorable to generate more gas in the west part than in the east part. Concerning the gas preservation, the features of geological structures, the surrounding rocks, coal rank, and coal body structure are all favorable to gas preservation in the west part and favorable to gas emission in the east part.

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