Research Journal of Applied Sciences, Engineering and Technology 6(21): 3959-3963, 2013
DOI:10.19026/rjaset.6.3496
ISSN: 2040-7459; e-ISSN: 2040-7467

Submitted: January 24, 2013 Accepted: February 18, 2013 Published: November 20, 2013

Research Article

Gas Distribution and Geological Controlling Factors of Huainan Mining

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Abstract: The aim of the study is to find out gas composition and distribution characteristic and analyze geological controlling factors of high gas content in Huainan mining, which is vital to the development and comprehensive management of mining area gas. Research on the law of gas distribution in the Huainan mining area shows that, the CH_4 content extend in N-W direction and NE higher than SW. CO_2 content in this mining performances that south is higher north, while the N_2 content shows a feature that south is lower than north. CO_2 content is high in the turn end of PanJi anticline and low in the wings of anticline. N2 content is on the contrary. Main factors of controlling gas content in this mining are coal quality, buried depth, coal thickness, geological structure and groundwater activity. In addition, gas content were positively correlated with coal quality, buried depth and coal thickness. Sealing fracture structure is beneficial to gas accumulation, while the open fracture structure will reduce gas content. Gas content decreases with the lithologic particle coarsening. Retention groundwater will make for methane's accumulation.

Keywords: Content, controlling factors, gas, Huainan mining

INTRODUCTION

Coal is contained within about $2.1\times10^3km^2$ in Huainan mining, where rich coal resource and Coalbed Methane (CBM) can be found (Shu-Xun *et al.*, 2011). However, because of the complex tectonic condition, reservoir of this mining is low permeability and high absorbability (Yuan, 2009). With the increasing of mining depth, the gas disasters of Huainan mining are more serious (Yuan, 2006; Jian-Ping *et al.*, 2009). Among the 11 coal producing mines, there are 7 gas outburst mines, 2 high gas mines and 2 low gas mines. The production of gas outburst mines and high gas mines accounted for 91.4% of the total output of the mining area. Nearly 200 coal and gas outburst accidents had happened since the mining area been built. According to the geological survey data and gas information of producing mines, gas content is fairly high in each coal layer; average content is $6.23m^3/t$, the maximum content can be $17.91m^3/t$. The gas is mainly conferred the B,C groups of middle coal measures, while in the lower A groups and its upper D,E groups, the gas content is relatively low, gas emission quantity of producing mines are relatively high. By the end of 2009, there were 146 coal and gas outburst dynamic phenomena in the mines of Huainan Mining Group, which includes 90 times in mining of south Huai River and 56 times in PanXie mining. 143 outburst phenomena belong to the central of B and C group coal beds and 2 times belong to the lower A groups (one is in A_1 coal seam of XinZhuang Zi mining and one is in A_3 coal seam of PanEr mining), 1 times happened in the upper D and E coal seams (D_{17} coal seam of PanEr mining), Table 1. So depth studying of the geological controlling factors and characteristics of gas distribution of mining area has great significance for the gas control, mine construction and promoting coal development safely and efficiently (Jia-Xuan, 2009).

The objective of this study is to find out gas composition and distribution characteristic and analyze the chief geological controlling factors of high gas content in Huainan mining. The researching results will provide support to develop coalbed gas efficiently and adopt reasonable gas measure to ensure mine safety.

Statistical characteristics of gas distribution: Among the gas composition of south Huai River mining, the hydrocarbon accounted for 78%, N_2 accounted for 18% and CO_2 accounted for 4%. For the XieYi mining, CH_4 from each coal seam (C_{13}, B_{11b}, B_{10}, $B_{9\ b}$, B_7. B_6, B_{4b}) accounted for 50.84~95.16%, N_2 accounted for 0.91~40.32%, CO_2 accounted for 0.51~21.01%; the average content of CH_4 accounted for 75.74%, N_2 accounted for 18. 03%, CO_2 accounted for 5.30%.

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Table 1: Characteristic table of gas content and outburst of coal seam

	South Huai River mining		PanXie mining		
Coal seam	Maximum gas content(m^3/t)	Times of outburst (time)	Maximum gas content(m^3/t)	Times of outburst (time)	Remarks
D_{17}				1	There are 90 times outburst happened in south Huai River mining (not list the 26 times outburst that occurred in the primary Xie-3 mining). The types of outburst are extrusion, pouring out, outburst and eruption. Gas content of PanXie mining is obvious higher in east PanYi mining and happened 56 times outburst totally.
C_{15}	11.05				
C_{13}	28.33	15	21.37	34	
B_{11b}	23.64	34	23.40	6	
B_{10}	10.64				
B_9	16.46	2			
B_8	15.54	2	24.26	4	
B_7	11.77		23.06		
B_6	9.39	4	24.14		
B_4	15.61	11	33.01	10	
A_3			18.87	1	
A_1		1	12.78		

In this mining, the gas content is between 0.08~21.71m^3/t, average is 8.71m^3/t; CO_2 content is between 0.04~17.54 m^3/t, average is 2.47 m^3/t. For the regional distribution, the CH_4 content extend in N-W direction and the CH_4 content of NE direction is higher than SW direction. The CO_2 content in this mining performances that the south part is higher than north, while the N_2 content shows a feature that south is lower than north.

Among the gas composition of PanXie mining, the hydrocarbon accounted for 50.14~97.92%, N_2 accounted for 0~44.63% and CO_2 accounted for 0~30.67%. Average percentage of gas composition is hydrocarbon 77.58%, N_2 16.55%, CO_2 5.87%. For the regional distribution, CH_4 content (south wing of TaoWang syncline) extend in NW direction totality and NE is lower than SW, CO_2 content is high in the turn end of PanJi anticline in this mining areas and low in the wings of anticline. N2 content is on the contrary.

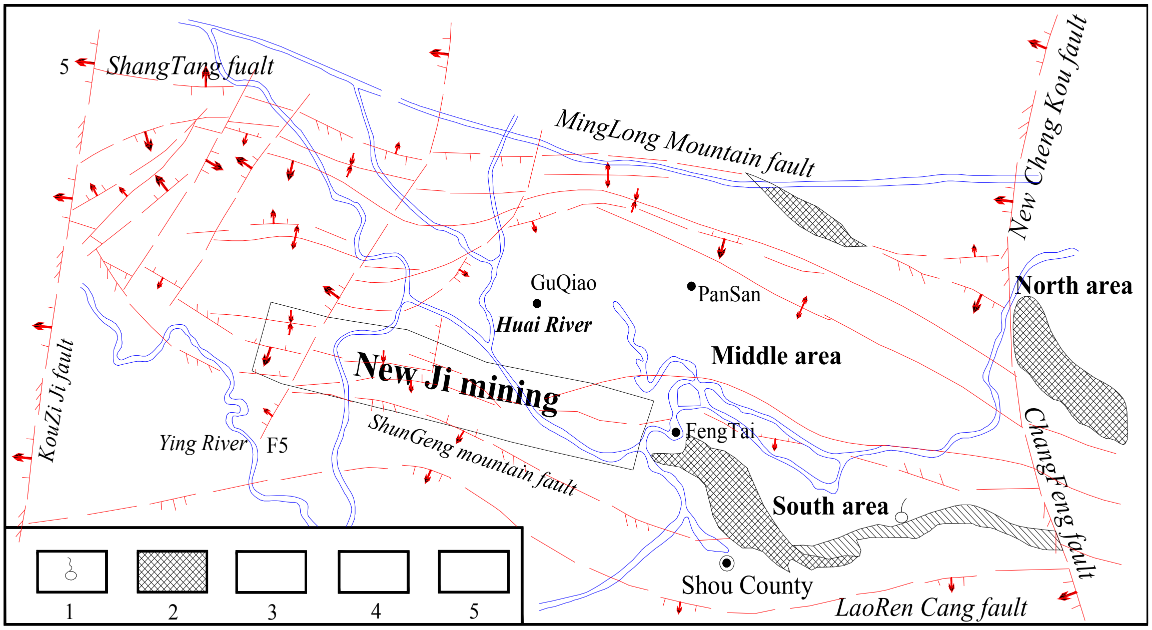
Gas geological controlling factors: Factors controlling gas distribution can be separated into two categories: One is original factor, which include coal character, coal thickness, wall-rock lithology and so on; another is epigenetic factor, include geologic structure, burial depth of the coal bed, groundwater activity and so on.

Coal bearing property control gas content: Coal bearing ratio of the Carboniferous Taiyuan formation in south Huai river mining is 3.98%. Maximum coal bearing ratio of Carboniferous coal-systems is 14.91%, the average is 6.35%. Coal bearing ratio of XieJia Ji mining is the highest area, reaching 11.15% and its gas content is also high, coal and gas outburst is most serious. By contrast, Coal bearing ratio of LiZui Zi mining is relatively low, so coal and gas outburst has not happened up to now. Coal bearing ratio of PanXie mining is 8.70%, coal and gas outburst is also serious.

Tectonic control gas content: In Huainan coal field the coal-bearing series are Carboniferous and Permian. Main structural framework is an EW ramp fault-fold structural belt (Chuan-Zhong *et al.*, 2005). Influenced by Tan Lu fault and Qinling latitudinal structural belt, the structure of south Huai River mining is complicated and fracture structure is developmental. The coal and gas associated structure styles include fault, fold and juxtaposition of the former two (Guo-Cheng *et al.*, 2003). Among them, fault is the main controlled factor of gas distribution. Gas occurrence is primarily depended on the impact of fault's closure and penetrability of rock.

Open fault (tension, tension-torsion, water conductivity) or good permeability rock connecting with coal seam will lead to nearby area gas content declining. Tension and tension-torsional fault are developmental in west and north of PanXie mining, west of DingJi mining and GuQiao mining. This is helpful for gas losing and gas content is lower. Although the F_1 fault of LiZui Zi mining is pressure and compresso-shear fault, its thrusting denuded the coal seam of hanging side. Because the dip of layer is vertical and cut by fault, coal seam will be disconnected by the large drop fault and contact with the good permeability rock formation on other side. In addition to groundwater activities, it is avail for gas letting, so this mining is low gas content area (Fig. 1).

Sealing fault (pressure, compressor-shear, water tightness) and bad permeability rock formation that connect with coal seam can prevent gas emission. So it is probable that forming gassy area in these mining. Brush structure region (F_{13-4}～F_{13-8} and F_{12-8}～F_{12-13}) of XieYi mining, for example, the coal body structure is destructed violently in the stress concentration part of brush structure's converging end. This causes gas concentration in the area. There are derivation faults developed inordinately in the Compressor-shear fault belts (F_{13-5-1}～F_{13-5}) and nearby. So these mining are large gas content regions with high methane pressure and concentrated ground stress (Fig. 1).



(1) Hypogene spring (2) Exposed limestone area (3) Water resistant fault (4) Precipitation recharge area (5) Stagnant area

Fig. 1: Tectonic and hydrogeologic map of Huainan mining

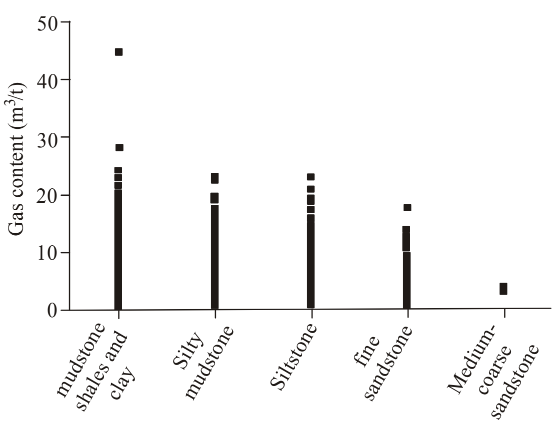


Fig. 2: Relationship between roof lithologic character and gas content

Groundwater activity control gas content: Ground water system controlled gas's absorption and aggregation by the reservoir pressure (Jian-Ping *et al.*, 2001; Hong *et al.*, 2005). The water-richness of Permian coal system in south Huai River mining is feeble. Units-inflow is ordinarily smaller than 0.1L/s.m. Permeability coefficient is smaller than 1. 13m/d. The water discharge of ton coal is about $1m^3/t$. Water content of coal bed is about 1.5% and the salinity is above 750mg/L. These figures illustrate that groundwater of coal series is ungated and lazy moving.

PanXie mining is the subject of synclinorium (eastern and middle). Owing to the effects of blocking water by the thrust fault located north and south wings (GuFeng fault and ShangYao-MingLong Shan fault), bedrock aquifer were cut off from the water source of exposed areas and composes closed hydrogeological unit. Groundwater in this area is also at a standstill. Therefore, aquifer of coal series in Huainan mining is relatively blocking and slow-moving. It is in favor of saving and enriching gas.

Roof lithologic character control gas content: Gas occurs in the coal seam. Permeability of roof can influence the gas content directly (Yu-Fen, 2006). The statistics result of Fig. 2 shows that, gas content decreases with the lithologic particle coarsening.

Main lithology of this mining's upper main coal seam and under main coal seam direct roof are shale and clay, account for 49.4%. Silty mudstone account for 32.8%, siltstone account for 11.5%, the other rock types only account for 6.3% (Table 2). Therefore, roof of this mining is more compact and helped to gas enrichment. Statistics to the gas outburst point of PanJi No.3 mining shows that, surrounding rock nearby the outburst point always have the characteristics of bad permeability, harder and denser (Guo-Wei *et al.*, 2008).

Burial depth control gas content: Burial depth is a key factor that control gas content. It can influence the pressure and preservation conditions of reservoir

Table 2: Roof lithologic characters of each coal seams in south Huai River mining

No.	Coal seam	Roof litho logy	Floor lithology
1	C_{15}	Mudstone, sandy mudstone,siltstone	Mudstone, sandy mudstone, siltstone
2	C_{14}	Mudstone, sandy mudstone,siltstone	Mudstone, sandy mudstone, siltstone
3	C_{13}	sandy mudstone, mudstone,siltstone	Mudstone, sandy mudstone
4	B_{11b}	Mudstone,sandy mudstone,fine siltstone, shale	Mudstone, sandy mudstone
5	B_{10}	Mudstone, sandy mudstone	Sandy mudstone, mudstone
6	B_{9b}	Siltstone, fine sandstone	Sandy mudstone, fine siltstone
7	B_8	Sandstone, sandy shale	Mudstone, sandy mudstone
8	B_7	sandy mudstone, mudstone	Sandy mudstone, fine siltstone
9	B_6	sandy mudstone, fine siltstone	Sandy mudstone, mudstone, fine siltstone
10	B_{4b}	sandy mudstone, mudstone	Mudstone, sandy mudstone
11	A_3	Sandstone, sandy mudstone	Sandy mudstone, siltstone

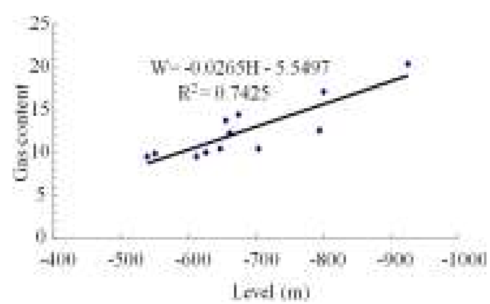


Fig. 3: Relationship between level and gas content of C13 among $F_{4\text{-}5}$(F_{17}) and $F_{13\text{-}5}$ in south Huai River mining

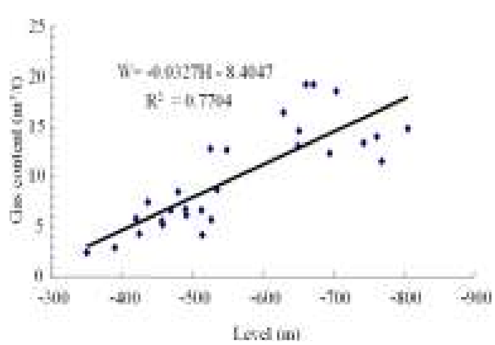


Fig. 4: Relationship between level and gas content of 13-1 coal seam from the footwall of F_5 fault to the wall of F_2 fault in south Huai River mining

(Xu *et al.*, 2002). The statistic shows that, the gas weathering areas depth is located 100-200m below bedrock. Thickness of Cainozoic is between 200-600m

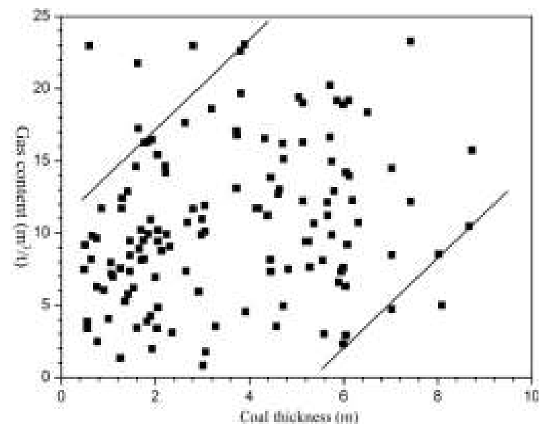


Fig. 5: Relationship between coal thickness and gas content of south Huai River mining

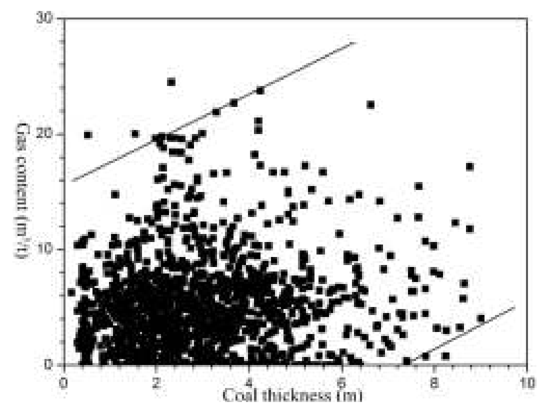


Fig. 6: Relationship between coal thickness and gas content of PanXie mining

(Jian-Hua *et al.*, 1999). Gas occurrence of Huainan mining was notably controlled by burial depth (Fig. 3 and 4). In the level of above -1000m, gas content increases with the buried depth. On the same burial depth, the smaller dip angle of coal seam, the higher gas content.

Coal thickness control gas content: Coal reservoir is a highly dense and low permeability rock formation. Middle stratification was sealed strongly by the up and down parts stratifications. The more coal reservoir's thickness, the longer travel that CBM diffusing from middle stratification to roof. Diffuse resistance is also bigger. It is helped to save CBM (Chong-Tao, 1999; Qin *et al.*, 2000). Gas content of south Huai River mining and PanXie mining correlates positively with the thickness of coal seam. When the thickness of coal seam further increasing, the gas occurrence ability of itself will be expressed to the maximum and the influence from thickness to gas content will decrease gradually (Fig. 5 and 6).

CONCLUSION

- CH_4 content of south Huai River mining extend in N-W direction and NE higher than SW. CO_2 content in this mining performances that south is higher north, while the N_2 content shows a feature that south is lower than north. CH_4 content of PanXie mining extend in NW direction totality and NE is lower than SW. CO_2 content is high in the turn end of PanJi anticline and low in the wings of anticline. N_2 content is on the contrary.
- Gas content of south Huai River mining is controlled by coal quality, buried depth, coal thickness, geological structure and groundwater activity. In addition, gas content were positively correlated with coal quality, buried depth and coal thickness. Open fault or good permeability rock connected with coal seam will lead to nearby area gas content declining. While the fault connected with coal seam is sealing and permeability, gas will concentrate. Gas content decreases with the lithologic particle coarsening. It will make for methane's accumulation when the groundwater keeps retention state totally.

ACKNOWLEDGMENT

Thanks for the funding by National Science and Technology of major special projects (2011ZX05034), National "973" CBM project (2009CB219605), Natural Science Foundation of China (41272178), Qing Lan Project and Priority Academic Program Development of Jiangsu Higher Education Institutions (PAPD).

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