

Research of Gas Deposit and Geological Regularity for Coalmine

Guo Xinyao^{1,2,4}, SONG Yinghua^{1,2,3}, Lv Wei^{1,2,3}, Guo Hui^{1,2,4} Li Xuyan^{1,2,3}

1.China Research Center for Emergency Management, Wuhan University of Technology,Wuhan 430070,China;2.Hubei Collaborative Innovation Center for Early Warning and Emergency Response Technology,Wuhan 430070,China;3.School of Management,Wuhan University of Technology, Wuhan 430070,China;4.School of Resource and Environmental Engineering,Wuhan University of Technology,Wuhan 430070,China

Abstract

In order to prevent the gas disaster and clarify the gas distribution situation regularity of the coalmine. According to the gas data of production and geological exploration in coalmine , we used gas occurrence tectonic gradual control theory researched gas geological occurrence regularity. We comprehensive studied of some important factors' effects on gas occurrence including geological structure, magmatic rocks distribution and overlying bedrock thickness. As well as we also made a theoretical analysis on outburst dangerous of this coalmine and then distinguished the danger of gas outburst zone. Putting forward significantly guide for the after safety production of this coalmine.

Key words: COALMINE; GAS GEOLOGY; GEOLOGIC STRUCTURE; COALMINE SAFETY

0. Introduction

Gas is the gas geological body of geologic origin, the complex geological evolution controls its formation conditions , storage conditions ,occurrence and distribution law^[1-2]. The formation of gas and the formation of coal were conducted at the same time and throughout the coal-forming period^[3] . Jia Cui, Wang Linyu, Yang Xu et al.used the gas geology theory forecasted the gas law in Yongju well Field^[4]. Zhao Zhigen, Zhang Mingming, Yan Jiaping reaserched the characteristics of gas geology in Yongshanqiao ming area, Jiangxi province^[5].Liu xiao and Zhang Ruilin based on gas geology theory and GIS technology developed a numerical gas geological map for better capture the gas geological characteristic^[6]. Gas emission , gas content and CBM (coalbed methane) resources of the coal seam are all controlled by the occurrence and distribution of gas . Only the using of tectonics theory about plate , the regional geological structure evolution theory and the tectonic sequential control on gas occurrence theory can reveal the mech-

anism of gas occurrence , the origin and development laws of tectonic coal ,and law of gas geology on different scales , and thus conduct gas predication and outburst risk predication accurately as well as reveal the mechanism of coal and gas outburst^[7-8] .

1. General situation of the experimental coalmine

The mine studied is 3.5 km long and 1.775 km wide , covering an area of 6.213 km³. The approved production capacity of the mine is 1.45Mt/a ;the mine development method is belt inclined shaft multi-level gathering main roadway partition crosscut exploitation ;there exist two levels of production at present .The second level elevation is at ±0m , the third level -100m , and the whole mine uses layering or single long wall caving ore method . After the accident in 2009 , the gas grade of the coal mine was a gas outburst one . With the development of production and horizontal extension for years , most of the coal seams in the mine have been known and mastered .

Combing this knowledge with such characteristics of coal seams as thickness, structure, spacing, roof and floor lithology, inter-layer lithology, index bed, coal seam group and logging traces, a comprehensive correlation was made and the coal seam correlation result was more reliable. However, as some coal seams thickened, thinned, split or were intruded and destroyed by igneous rock, the coal seam correlation was influenced to some degree. Throughout the occurrence of coal seam in this area, the total thickness of the coal-bearing strata and the thickness of the coal seam itself gradually tend to become thinner from east to west and south to north, and the coal seams seem to be thinning and splitting.

No.22 seam in the coal mine is one of the main mining coal seams with a total thickness of 3.0~8.0m and its structure is simple. Its roof is composed of coarse sandstones; the thickness of the upper seam varies between 0.70~5.0m; there are beige fine sandstones with a thickness of 0.2~0.5m in the middle part; the lower seam measures 2.0~3.0m with a spacing of 40~55m from No.21 seam, generally 45m.

No.27 seam measures 3.0~3.7m, and there are beaded yellowish fine sandstones of about 0.10m in the middle, which is an important mark of the seam. 1.0m under the bottom is a coal line of 0.05m, with a spacing of 15~25m from No.22 seam.

2. Geological structure and characteristics of the mine field

The strike direction of the coal mine is along NE 15°~30° or so with a dip angle of 15°~30° in southeast inclination. The major faults in the eastern and western mining area is the sedimentary faults that control the basin, which turns the basin where the mine lies into a closed continental fault basin. The structure within the mine field is more complex; it is characterized by faults, with slightly minor folds and accompanied by a variety of intermediate-acidic volcanic rock and sub-volcanic rock activities. This demonstrates the existence and multi-phase impact of Yanshan movement. For many years, the mining practice proved that this mine is the most complexly structured one in the whole mine field, especially the production areas of the first and second wells. Based on the order of faults and the cutting relation of the whole field, it can be comprehensively analyzed as two phases of tectonic movement. The first phase of tectonization is mainly the major fault in north-west direction. The second is the medium-sized fault derived in the first phase, with a drop of over 50m. There are three large thrust faults controlled by several roadways. Within the mine, small faults are well-developed and criss-crossed, cutting the coal-bearing strata into a number

of small sections. On the boundary of each mining area, small structures derived from large and medium-sized faults extend directly to the mining face, bringing difficulties to normal continuity and production.

3. Research of gas and geological regularity for coalmine

3.1. The influence of faults and folds on gas occurrence

Through the analysis for the geological evolution of the mine field, the coalmine's general structure has the following characteristics: its strike is nearly SN, tend to SEE monocline, and the regional folds are underdeveloped with folds existing only in some areas. The principal stress orientation of recent tectonic stress field is in NE direction, and the structure in NW direction is influenced by extrusion, controlling the gas occurrence characteristics of the mine field. Near the fault in NE direction, the coal body was seriously damaged by extrusion, gas deposit is rich, and the coal seam stress is concentrated. In the process of mining, coal and gas outburst dynamic phenomenon often occurs in this area, and the gas outburst place of this mine happens to be of such a geological structure.

The coalmine studied is located in the far north side of the mine field. Faults are the main structure of the coalmine, and the faults develop densely yet with certain occurrence regularity and development characteristics. Due to the large structure effect of the regional stress field, the coalmine is a typical rotational shear structural brush, converging to the north and diverging to the south, as shown in figure 1.

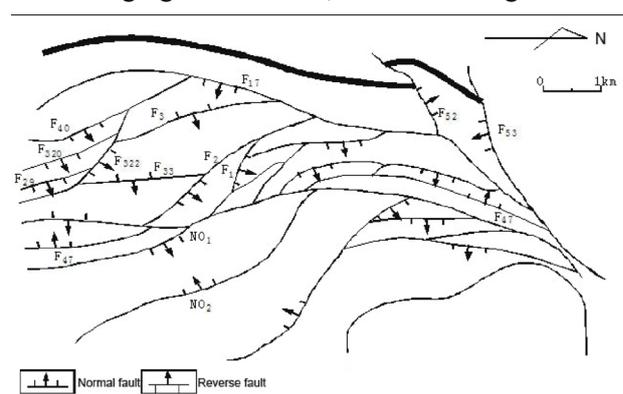


Figure 1. Structure outline map of the coalmine

The main faults of the coalmine are those in nearly SN direction and there are F_{17} and F_{47} faults. Owing to the effect of tectonic stress field, they show certain openness, accelerating gas release of the coal seam.

The NW-NNW medium-sized faults derived from major fault structure, such as F_1, F_2, F_{322} and other normal faults and F_{33}, F_3, F_8 and other thrust faults,

also show certain closeness , hindering gas release of the coal seam .

In addition , influenced by boundary faults F_{17} , F_{49} and area faults F_{10} , medium and small faults are well-developed and interconnected , the coal seam is badly destroyed and a large quantity of fractures

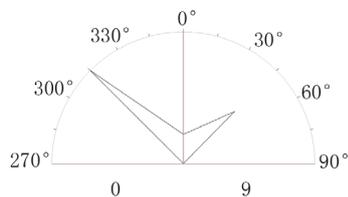


Figure. 2 The rose diagram of positive faults trend

appear within the coal body , making the internal surface area of coal increase significantly and thus making a great amount of gas adsorbed and stored .The rose diagram of mine fault strike is shown in figure 2 and 3 .

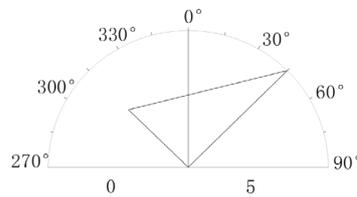


Figure. 3 The rose diagram of thrust faults trend

3.2. The influence of roof and floor lithology on gas occurrence

The permeability of coal seam wall rock directly affects the coal seam gas occurrence , migration or enrichment . The permeability coefficient of sandstone , conglomerate and limestone with pore and fracture development is very large , generally more than a thousand times larger than that of shale , mudstone etc. which are dense and without fracture development . As the sandstone roof with good permeability contributes to coal seam gas dispersion , the coal

seam gas content is relatively low ; since the mudstone or sandy mudstone roof with poor permeability hinders coal seam gas dispersion , the gas content is relatively high .

The roof of No.22 coal seam of the coalmine consists of sandstone , siltstone , and its floor of fine sandstone . The coal seam comprises two layers with tuffaceous siltstone of 1.8m or so in the middle . The roof of No.27 coal seam is composed of siltstone and the floor of fine sandstone as well as tuffaceous siltstone as shown in table 1 .

Table 1 . Coal seam roof and floor lithology comparison chart

Coal Seam	Roof Rock	Interlayer	Floor Rock
22	Fine Sandstone , Siltstone	Tuffaceous Siltstone	Fine Sandstone
27	Fine Sandstone	Siltstone	Fine Sandstone Tuffaceous Siltstone

Fine sandstone and siltstone , especially tuffaceous siltstone have a poor permeability and thus gas can only migrate along the coal seam instead of dispersing through the rock formation . This leads to the storage of gas . Consequently , gas content is high and gas emission increases.

3.3. The influence of magmatic rock distribution on gas occurrence

Magmatic rock intrusion causes damage to coal seam continuity and it is also one of the important factors affecting gas occurrence distribution . The mine magmatic activity is controlled by nearly SN and NW faults and the activity law increases its frequency from south to north and west to east . The plutonic intrusive rocks and extrusive rocks are the dominant components . The intrusive rocks mainly include Proterozoic intrusive rocks , Variscan intrusive rocks and Yanshanian intrusive rocks , and they mainly exist in the northern and western base of the coal field . The extrusive rocks are given priority to Yanshanian and Hymalyan volcanic activity , existing

in the eastern and northwestern coal field . The magmatic intrusion causes contact metamorphism of the coal seam , improves the coal metamorphic grade ,and increases the coal seam gas generation quantity . The coal types of the coal field present obvious band distribution rules . The deeply metamorphic grade of the same metamorphic belt gradually increases from north to south^[9] , as shown in figure 4 .

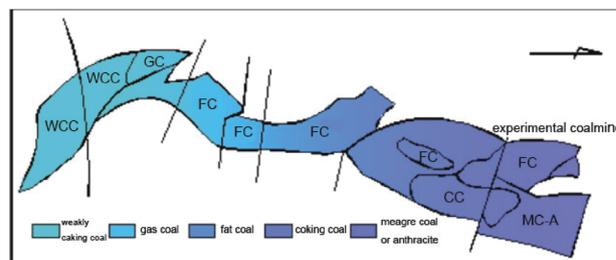


Figure 4. Distribution of coal type in the coal field^[9]

Due to magmatic rock intrusion, the coal seam gas generation quantity increases. Consequently, gas content of the experimental coalmine located in the northeast is higher than that of all the coalmines in the south under equal elevation. As along the tendency of coal seam, the metamorphic grade increases with the buried depth deepening, and shows an increasing tendency from the shallow to the deep, deep coal seam gas content is significantly higher than that of shallow coal seam.

The mine magmatic intrusion is mainly along the fracture zone of F_{16} thrust fault, and most of the coal seam in the upper wall of F_{16} thrust fault has been intruded and damaged. The two mines—northern mine and southern mine exploited by 81513 mining team are both located in the upper wall of F_{16} thrust fault. Their working seam are No.12, No.13 and No.15 natural bed, which are all damaged by igneous rock intrusion. As igneous rocks generally are generated by dikes, 50% of the coal seam are turned into natural coke, and the coal seam roof and floor are both damaged. Therefore, the coal produced is almost half coke.

3.4. The influence of overlying bedrock thickness on gas occurrence

The coal seam overlying bedrock thickness equals to the buried depth minus sedimentary thickness of the Quarternary loess and quicksand stratum. Quarternary strata are mainly loess formation and quicksand stratum, mainly existing in the earth's surface. It has a large porosity and good connectivity, and its poor cementation is helpful to gas release. Therefore, the influence of overlying bedrock thickness on gas occurrence is more convincing than that of buried depth of coal seam or elevation.

The bedrock thickness of each drilling can be calculated based on the histogram of each drilling. On the gas geological map, the gas content prediction model established on the basis of bedrock thickness can most effectively reflect the actual gas occurrence regularity. Gas content of several typical coalmines can be back calculated by combining existing data of mine gas pressure and absolute gas emission quantity with relevant regulations. Then the regression trend line of gas content and overlying bedrock thickness of No.22 and No.27 coal seam can be drawn through linearity regression, as shown in figure 5 and figure 6

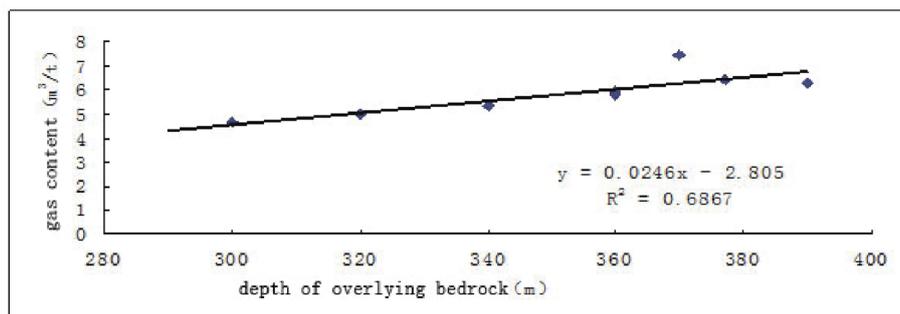


Figure 5. Correlative chart between gas content and NO.22 seam depth of overlying bedrock

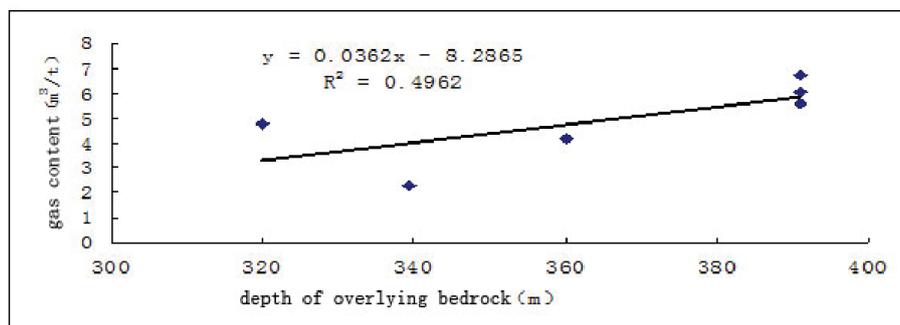


Figure 6. Correlative chart between gas content and NO.27 seam depth of overlying bedrock

4. The analysis of outburst risk

A major coal and gas outburst accident occurred to the coalmine studied in 2009, and No.15 coal-seeking roadway in the trailing section of No.2 crosscut on level 3 was the outburst area. The coal and gas outburst occurred in the process of mining with coal outburst quantity of 3100m³ and gas outburst quantity

of 170000 m³. In order to better settle the problem of field gas control and improve outburst prevention effect, it is necessary to further analyze and study the factors affecting coal and gas outburst.

4.1. The relationship between coal thickness and the structure change of coal seam and gas outburst

The thickness of No.22 coal seam is 3.0~8.0m, and the coal seam becomes thinner from south to north. It is the coal seam with the greatest thickness change in the coalmine. The thickness of No.27 coal seam is 3.0~3.7m; in general, it also becomes thinner from south to north and from east to west. However, its overall thickness is less than that of No.22 coal seam, and its thickness change is less stable.

The unstable state of gas occurrence caused by the uneven distribution of coal seam thickness causes the directional migration of gas. The gas migration from areas of large thickness to those of smaller thickness and from areas with high gas content to those with lower gas content results in the phenomenon that gas emission increases drastically in those areas of small thickness. This will lead to coal and gas outburst easily.

4.2. The relationship between geological structure and gas outburst

Coal and gas outburst risk is closely related to geological structure. Due to the effect of ground stress and the complexity of stress field, the degree of stress concentration is different in the same structural feature. This drives gas migration and relative enrichment, causing relatively high gas pressure areas and low gas pressure areas and forming various favorable conditions for gas deposit or emission.

As the coalmine is influenced by boundary faults F_{17} , F_{49} and area faults F_{10} , medium and small faults are well-developed and interconnected, the coal seam is badly destroyed and a large quantity of fractures appear within the coal body. This makes the internal surface area of coal increase significantly and makes a great amount of gas adsorbed and stored. As a result, local gas enriched areas come in to being easily, threatening the normal production of coalmine.

4.3. The relationship between tectonic coal and gas outburst

The tectonic coal in the coalmine is also an important factor causing coal seam gas outburst. Regional tectonic extrusion and shear stress concentration belt as well as intense tectonic deformation zone tend to be the places where gas enrichment occurs and the development of tectonic coal is severely damaged. Gas outburst coal has characteristics of both severely damaged tectonic coal layer and high energy gas, which is essential to induce coal and gas outburst^[10].

According to the underground observation, in No.22 and No.27 coal seam geological structure belt, the luster of the coal body is semi-dull; the joints are unclear; the fractures are irregular and granular. Besides, the coal body turns into fines appearing in powder form after it is twisted by hand, and it has a

low hardness. This shows that the coal body mainly belongs to coal of class III or IV. After research and verification, the coalmine studied generally generates tectonic coal of II or III type; tectonic coal of III or IV type develops relatively well within geological structure influence scope; the consistent coefficient f value of coal more often than not is 0.24~1.01. Tectonic coal of III, IV type has a low hardness, and in the areas where it is quite developed, coal and gas outburst accident occurs easily.

4.4. Prediction of outburst risk

According to China's *Provisions on Coal and Gas Prevention*, as outburst occurred to No.22 coal seam of the neighboring coalmine, No.22 coal seam of the coalmine studied is assumed as outburst coal seam and requires outburst risk prediction. Based on the basic parameters of gas in the coalmine studied, it can be seen that the coal seam with a gas content of 8 m³/t has a buried depth of 450m and that the area below the depth is outburst potential area. In terms of No.27 coal seam, it can be seen that the coal seam with a gas content of 8 m³/t has a buried depth of 439m, and that the area below the depth is outburst potential area. Based on the definition of outburst potential area, in the process of deep mining, regional targeted preventive measures should be put forward in the respect of coal and gas outburst prevention.

5. Conclusion

1. Geological structure analysis for the coalmine: The main faults of the coalmine studied are those in nearly SN direction and there are F17 and F47 faults. Owing to the effect of tectonic stress field, they show certain openness, accelerating gas release of the coal seam. The NW-NNW medium-sized faults derived from major fault structure, such as F1, F2, F322 and other normal faults, F33, F3, F8 and other thrust faults, also show certain closeness, hindering gas release of the coal seam.

2. The mine magmatic intrusion is mainly along the fracture zone of F16 thrust fault; the working seam in the upper wall of F16 thrust fault has been damaged by igneous rock intrusion; 50% of the coal seam are turned into natural coke, and the coal seam roof and floor are both damaged. Meanwhile, as the magmatic intrusion accelerates metamorphism of the coal, the coal seam gas content increases accordingly.

3. The control function of coal seam roof and floor lithology and overlying bedrock thickness etc. on gas occurrence is analyzed, and linearity regression has been made about gas content.

4. Outburst risk factors have been analyzed in such aspects as coal seam thickness, coal body structure, geological structure and development degree of tectonic

coal ; outburst potential area has been defined according to the field data . Furthermore , preventive measures aimed at corresponding areas have been worked out for deep mining in order to ensure the safety production of coal mine .

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