The Study of Control Action of Fault on Coal and Gas Outburst

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Abstract: The results show that coal and gas outburst has the characteristics of control structure, segmented variability and uneven regional distribution, affected and controlled by the geological structure and stress in time and space. The examples of coal and gas outburst show that most of coal and gas outbursts occur near fault, indicating fault has obvious controls on coal and gas outburst. The existence of fault gouge and accompanying crack in the coal petrography near fault is conducive to the existing and migration of gas. The compression and stretching produced during the formation of fault promotes the formation of structural coal, which are prepared power base for coal and gas outburst. Fault with material and power base promotes the frequent occurrence of coal and gas outburst. This regularity understanding has important theoretical and practical significance to reveal the occurrence mechanism and regional forecast of coal and gas outburst.

Keywords: coal and gas outburst; control action; geological structure; fault

1. Introduction

Coal and gas outburst is a major disaster in coal mine. It is a very complex dynamic phenomenon occurred in the process of underground mining. It behaves in a few following respects: a large number of coal and gas are suddenly thrown to the roadway space, resulting in the people are buried by the coal flow, full of gas in roadway, choke, or even cause explosion. Coal is main energy in our country. In 2005, national coal output reached 2.19 billion tones, and in 2006 reached 2.386 billion tones, in 2007 reached 2.536 billion tones. In 2008 reached 2.622 billion tones, in 2009 reached 2.965 billion tones which is the highest output in the world, 95% of coal mines in our country belong to underground mining. Owing to the objective factors, the mine disaster is very serious. In grave accidents of coal mine, above 70% are gas accidents. The number of deaths accounts for about 40% of total deaths of mine accidents[1]. In 2006, there were 40 coal and gas outbursts, 252 people died; in 2007, there were 35 coal and gas outbursts, 248 people died; in 2008, there were 34 coal and gas outbursts, 278 people died. The occurrence of outburst disasters not only threats seriously the lives of coal miners, but also restricts seriously the efficient and safety production of coal mine and national economic development. For a long time, because of the complexity of outburst mechanism, people have done a lot of qualitative analysis and preliminary quantitative study on the reason of coal and gas outburst. People generally believe that coal and gas outburst is the result of the combination of stress, gas and coal structure. The statistical analysis by a large number of outburst examples shows that coal and gas outburst region accounts for only 10%-20% of the entire mining region[2], and concentrates in the construction zone.

2. Effects of Geological Structure on Coal and Gas Outburst

Professor Yang Lisheng, the founder of mining gas-geology believes that[3] geological structure has different times, different size, different combinations and has different influence on the control of seam gas .The gas emission and outburst changes of national mine are controlled by the terminal structure. Terminal structure refers to the small faults and changes of coal thickness exposed by underground mining.

Huang Desheng believes that[4] the structure is controlled step by step that are large structure controls medium structure and medium structure controls small or micro-structure. As the different of the geological structures size, the control situation on the gas is different. Large structure is regional structure which controls the occurrence and outburst of gas; medium structure is ribbon control; small and micro-structure is local point control.

Geological structure is a shape left by the crustal movement, the different geological structures appeared not only in different coalfields, but in the same coal field, and the same coal seam or a small area of the coal seam structure will also change. Geological structure has an important influence on coal and gas outburst. According to fracture mechanics and structure in its formation process, control action of fault on coal and gas outburst has its own characteristics.

3. Control Action of Fault on Coal and Gas Outburst

Liu Xianwei's analysis on the geological structure type near outburst point of Beipiao coalfield shows that there are 391 outbursts which occurred near fault,

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accounting for about 36.3% of the total outbursts. in 220 outburst that is not incomplete statistics, there are about 187 times related with normal faults, accounting for 85%; and 33 times related with reverse fault, accounting for only 15%[5].During the mining process of Beipiao mine area (Table 1), from fault closer, the times of outbursts more often, but the strength of outburst is not necessarily large. There is largest number of outbursts within 10m away from fault, but the strength is relative small; the strength of outburst becomes larger away from fault. As to the small faults whose fault throw less than 10m ,the number of outburst is more, but the strength is small[6].

Practice shows that there is a close relationship between fault and coal and gas outburst , then what is the control mechanism of fault to coal and gas outburst? During the formation of fault, what kinds of impact it has on ground stress, seam gas and physical-mechanical properties of coal mass? I will discuss below.

Table 1 Relationship between coal and gas outburst and fault in Beipiao mine area

The relationship between outburst and fault					
Fault Throw(m)		The number of outburst(time)		Average Strength(t/time)	
<10		268		28.4	
10～20		43		29.8	
>20		80		44.55	
The distance between the point of coal and gas outburst and fault					
Distance (m)	0～10	10～20	20～30	30～40	40～50
Number (time)	215	111	38	18	9
Average strength(t/time)	29.35	31.94	35.20	34.20	28.70

3.1. Effects of fault on crustal stress

Crustal movement creates a variety of geological structures, forming tectonic stress field which changes the size, direction and distribution of the original stress. High crustal stress is the first necessary condition that causes coal and gas outburst to occur. The sudden change of stress state is the second necessary condition that causes coal and gas outburst to occur .The formation of fault prepares such conditions for coal and gas outburst.

(1) The formation of fault is an expression form of plate movement and energy release. Its formation destroyed the balance of original stress field and formed a new tectonic stress field which is easy to change and wave. In the formation of fault, coal rock mass will cause relative displacement, as the deformation of coal rock formation is not sufficient. There may be some tectonic stress which are stored in the coal mass in the form of elastic deformation potential, the stress is concentrated around fault, all these provide power sources for coal and gas outburst.

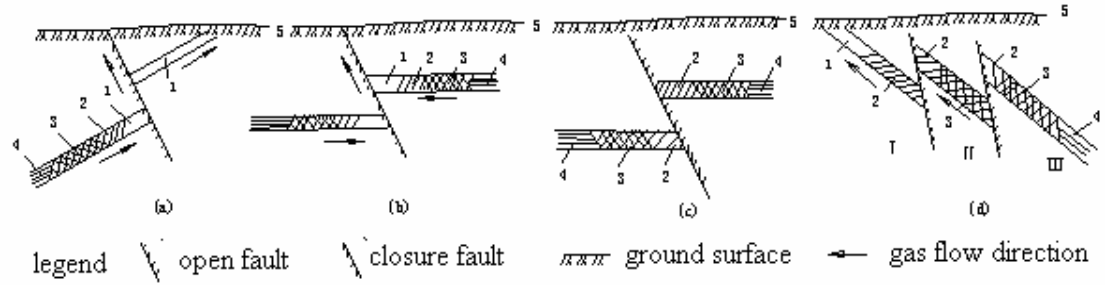

Fig.1 Effects of fault on coal seam gas

1- Gas dissipation area 2 - Gas content decreasing area 3- Gas content abnormal increasing area 4- Gas content normal increasing area

(2) The different formation of fault has different influence on stress field. In general, in the overthrust fault, the coal and rock of fault bottom are squeezed and kneaded strongly, strong tectonic deformation will occur, the stress is high, it has more dangerous and destructive compared with the outburst of normal fault.

3.2. Effects of fault on coal seam gas

Generally, there will be some either thin or thick exquisite ooze membranes with exquisite and compact structure left on the fault surface after the fault has been formed. Broken coal rock fragments are visible inside some fault zones, while large amounts of exquisite ooze are filled within the fragments. Meanwhile, on the both sides of the fault zone, there also exists ooze membranes structure made up of coal rocks on the fault surface, which forms a sealing surface. However, a series of open ended accompanying microscopic fractures or crevasse is developed inside the coal rocks near the fault walls,

while the ooze membranes seen in the faults surface is rarely visible inside the crevasse. Such accompanying microscopic formation not only can benefit gas storage, but also benefit the migration of gas.

It is complex for the fault effecting on gas content. On the one hand, it depends on the closure of fault (Zone). On the other hand, it depends on the air permeability of the matching rock which contacted with coal seam. Generally, the open fault (tensile, tenso-shear or leading fault) may lead the gas content of coal seam which is close to fault to decrease. When the air permeability of the matching rock contacted with coal seam is high, the decreasing range for gas content would be larger (refer to picture 1a,b).When the air permeability of surrounding rock of coal seam in the closure fault (compressional, compresso-shear, un-leading fault) is low, which could prevent from gas of coal seam discharge, under this condition, high volume gas content would concentrate in coal seam. For the fault concentrating stress zone, the gas permeability of rock and coal seam which has some distance to fault would decrease because of extrusion, so when forming gas increase zone. Fig.1d refers to division status of gas content when coal seam divided to three blocks by two closure reverse fault. Section block Ⅰ coal seam outcrop through the grant, and no gas supply from the below, so the gas content of coal seam is low. The above and below of section block Ⅱ is trapped by closure fault, the gas of the above loss not much, meanwhile, no deep gas supply from the below, so the gas content of coal seam is more than that of Block Ⅰ. The above of section block Ⅲ is closed by fault, and deep gas supply from the below, the gas content is larger compared to other block with the same level.

3.3. Effects of fault on the physical-mechanical properties of coal mass

The stress concentration produced during the formation of fault has affected the original existing state of coal seam, which will occur the physical and chemical changes, and form the deformed coal around the fault. The physical-mechanical properties possessed by the deformed coal, to a great extent, improve the occurrence of coal and gas bursting.

For the effect of tectonic stress, for one thing, it would enable the coal mass to produce dense fissure, the structure of coal mass is then damaged, and the mechanical strength of coal mass is reduced, while its ability against outburst is also reduced, which decreases the outburst resistance and its energy required; For the other, if the structure of coal mass is damaged, the pore space and internal surface area will increase, which may store more free gas. As the poor gas permeability of deformed coal, the gas pressure can generally maintain in a high level. Meanwhile, by the action of tectonic stress, the structure of coal mass is damaged. The fragments squeeze, clash and knead against each other, become progressively smaller, and even turn into the powder by the action of other high strength. It makes the coal and gas outbursts more liable to occur.

3.4. Control action of fault

In conclusion, the control action of fault on the coal and gas outbursts is significant, During the process of coalification and metamorphism, the tectonic movement can promote the produce of gas; the formation of fault damages the structure of coal mass, and reduces the resistance for the occurrence of coal and gas outbursts; the produce of fault may form the enclosure space available for gas accumulation. Besides, the tectonic stress field controls the gas migration, which is a prominent important link for the gas occurrence. The tectonic stress field determines the migratory direction and track of gas: the gas migrates from the high stress difference area to the low area, and aggregates in the low stress difference area. The coal and gas outbursts is liable to occur near the piezotropy fault, which is just the synthetic performance of tectonic stress field and deformed coal in the temporal and spatial coupling. The formation and growth of fault affects the occurrence of coal and gas outbursts in terms of the crustal stress, gas and structure of coal mass. See table 4 for details.

Table.2 Relationship of gas distribution near fault[7]

grustal stress	Original pressure zone---boost pressure zone---decreasing pressure zone--- boost pressure zone--- original pressure zone (stress concentration zone) (stress release zone) (stress concentration zone)
gas	constant---peak---valley----peak---constant (concentrated outflow zone) (decreasing zone) (concentrated outflow zone)
structure of coal mass	Primary texture--- ruptured zone---mylonitic texture---textures of clastic grains-- primary texture (Including fault gouge)

4. Conclusions

(1) With the produce of tectonic stress field, the balance of original stress field is damaged, and the local stress concentration is then formed, storing the residual energy in the coal-rock mass, which provide the dynamic basis for the coal and gas outbursts. The fault gouge, crevasse around faults and the closed construction

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provide the conditions to the storage and migration of gas, and provide the material basis for coal and gas outbursts. The broken coal mass of deformed coal formed under the action of tectonic stress, along with the low strength, making the required resistance and energy of coal and gas outbursts decrease, which provide the environmental basis for the coal and gas outbursts.

(2) With the increase of mining depth, the effects of geological factor on seam gas preservation also progressively increases. Apart from the fault, the geologic structures such as fold, igneous rock intrusions have the different controls on the coal and gas outbursts. The Occurrence of coal and gas outbursts has obvious zonation.

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