2011 Xi’an International Conference on Fine Geological Exploration and Groundwater & Gas Hazards Control in Coal Mines

Water Disaster Types and Water Control Measures of Hanxing Coal Mine Area

Chao Xu*, Pingping Gong

Hydrogeological, Engineering Geological and Environmental Geological Exploration Institute, CNACG, Handan, Hebei 056004, China

Abstract

Hanxing coal mine area is a typical karst high-water deposit. With further exploration of under-group coal seams, various threats of water disasters came. Coal water disasters can be divided into five types through comprehensive study on geological and hydro-geological conditions of the coal mine area. The five kinds of water disasters are surfer water disaster, coal roof aquifer water disaster, coal floor high-pressure Ordovician karst water disaster, goaf water disaster and karst collapse column water disaster. For all types of water disasters, corresponding water control measures were proposed and these water control measures are of great theoretical and realistic significance to the mine safety and high-level decision in Hanxing coal mine area.

© 2011 Published by Elsevier Ltd. Open access under CC BY-NC-ND license. Selection and peer-review under responsibility of China Coal Society

Keywords: Hanxing coal mine area; goaf water; collapse column; water disaster type; water control measures

Hanxing coal mine area is one of China's major coal production bases, is located in southern Hebei Province, including Handan and Xingtai regions. Amounted to 5.3 billion tons of coal resources, for the protection of national energy security and the development of the local economy has great significance. In this area, there are Jizhong Energy Group Co., Ltd. who includes Fengfeng Handan and Xingtai three mining groups and more than 50 local coal mines. Hanxing coal mine area is a typical karst high-water deposit[1].With long history of mining, land subsidence, ground fissures, water environment problem have

* Corresponding author. Tel: +86-310-8908007; fax: +86-310-8908091. E-mail address: xuchao713@163.com.
come into focus, especially with the increased depth of mining, deposits water, in particular, Ordovician limestone rock water has become a constraint of mining\cite{2,3}. Summary analysis of mine water disasters and study on water control techniques for further mine water control work are of great theoretical and realistic significance to the mine safety and high-level decision in Hanxing coal mine area\cite{4}.

1. Geologic and hydro-geologic background of Hanxing coal mine area

1.1. Geologic background

The area belonged to North China stratigraphic region, controlled by Neocathaysian structural system. Formation strike is NE-NNE, dip direction is SE and dip angle is 10° to 25°. More complete formations are exposed over the whole region, from the old to the new mining strata is: Archean, Proterozoic, Cambrian, Ordovician, Carboniferous, Permian, Triassic and Cenozoic Paleogene, Neogene, Quaternary.

In this area, the main coal-bearing strata are Carboniferous Taiyuan Formation and the lower Permian Shanxi Formation, the total thickness is 170 to 250m, average 190m. Taiyuan Formation includes 7-15 coal seams, the major minable and part minable coal seams are 4#(Yeqing), 5#(Shanqing xiao), 6#(Shanqing), 7#(Xiaoqing), 8#(Daqing), 9#(Xiajia), total thickness of coal seams is about 11.26m, total thickness of minable coal seams are about 9.02 meters, minable coal bearing ratio is 7.5%. Shanxi Formation includes 1-4 coal seams, Coal 2#(Damei) is the major minable coal seam, thickness 0.9-9.47m, average 5.51m, total thickness of major minable coal seams is 5.13m, minable coal bearing ratio is 7.3%. The lithologic characters, facies, coal and spacing are all stable, shown in Fig. 1.

1.2. Hydro-geologic background

Hanxing coal mine area is located in Xingtai Baiquan spring area, Fengfeng Heilong dong spring area, Shexian Dongfeng hu spring area three separated hydro-geological units. The area was significantly affected by construction, lithology, hydrology and other factors, led to more complex hydro-geological conditions. Three main types of aquifer formations, a total of seven aquifers can be divided according to groundwater occurrence, physical properties of water and hydraulic characteristics, shown in Table 1. The uneven thickness water-resisting layer which composed by mudstone, aluminum mudstone, sandstone,
partially magmatic rocks between aquifers. Major source of groundwater recharges of precipitation. Currently the main modes of groundwater excretion are coal mine drainage, iron ore drainage, water supply, industrial and agricultural exploitation and Heilong dong spring row.

Table 1. Aquifer division table of Hanxing coal mine area

| Aquifer formation type | Aquifer                                                   |
|-----------------------|----------------------------------------------------------|
| Quaternary loose rock pore aquifer formation | Quaternary loose rock pore aquifer |
| Permian sandstone fracture aquifer formation | Permian Shihezi Formation sandstone fracture aquifer |
| Permian Shanxi Formation Damei roof sandstone fracture aquifer | Carboniferous Taiyuan Formation Yeqing limestone karst fissure aquifer |
| Carboniferous Taiyuan Formation Fuqing limestone karst fissure aquifer | Carboniferous Taiyuan Formation Daqing limestone karst fissure aquifer |
| Carboniferous Taiyuan Formation Daqing limestone karst fissure aquifer | Middle Ordovician limestone karst fissure aquifer |

2. Water disaster type of Hanxing coal mine area

Coal water disasters are divided into five types through comprehensive study on geological and hydrogeological conditions of the coal mine area. Five kinds of water disasters are surfer water disaster, coal roof aquifer water disaster, coal floor high-pressure Ordovician karst water disaster, goaf water disaster and karst collapse column water disaster.

2.1. Surface water disaster

Water system is very developmental in this area. Many reservoirs located everywhere and some of surface water flows through the upper of mines. This surface water is major floods when shallow coal seam is mined. First, surface water may enter the mine through a number of ways, such as structural belts, cracks due to mining, drilling bad closed and so on. Second, surface water may be used as source of groundwater, infiltration gradually, and then enter the mine through other ways. Again, Floods triggered by heavy rains is major surface water damage. For example, January 9, 1992, Wannian coal mine water inrush incidents occurred at its 13202 coal chute cross cut. The reason is the water of Yuefeng Channel entered.

2.2. Water disaster of the coal seam roof aquifer and above aquifer

1) Quaternary loose rock pore water disaster

Most of the coal mines are covered by uneven thickness Quaternary, pore water of loose layer may inrush into mine through the fault zone, the roof fracture zone and the mine collapse, and lead to mine water disasters.

2) Shihezi Formation sandstone water disaster.

Shihezi Formation sandstone fissure water is in the upper coal-bearing strata, and water rich in some areas. Parts of this area, the coal seam roof hydraulic conductivity fracture zone or fault zone are connected to Shihezi Formation sandstone, and resulting sandstone fissure water into the mine, usually
rendered as head watering in the tunneling process, and difficult to be completed dewatered. In 1974, Wannian coal mine, sandstone water entered the mine due to the fault, and lead to mine water disasters.

(3) Damei roof sandstone water disaster
The roof sandstone is indirect roof of 2# coal seam; in some areas is direct roof. The sandstone water is mainly fissure water and pore water, water-rich heterogeneity. In the process of 2# coal mining, the mine water is generally in the form of leaching stream and deteriorated the production environment. The water is easy dewatering, in the case of no hydraulic connection. Every coal mine suffers this Damei roof sandstone water disaster.

(4) Taiyuan Formation thin-bedded limestone water disaster
Yeqing limestone is the direct roof of 4# coal seam, water-rich, but easy to dewatering. Fuqing limestone is indirect floor of 6# coal seam, uneven water-rich and easy to dewatering. Daqing limestone is the direct roof of 8# coal seam, uneven water-rich and water-rich parts of strong. Taiyuan Formation thin-bedded limestone occur hydraulic connection with Middle Ordovician limestone water in the case of fault structure. And this phenomenon is a tremendous threat to mine safety.

2.3. Coal floor high-pressure Ordovician karst water disaster
Middle Ordovician limestone is region's base of coal-bearing strata. The water in this stratum is high-pressure. The stratum is strong permeability and water-rich. In this mining area, a large area of limestone outcrop distributed in the Midwest, accepting the precipitation recharge. As the thickness and good connectivity in a wide range, it is very easy to have hydraulic connection with coal-bearing aquifers due to the fault communication. So the high-pressure Middle Ordovician karst water is the largest threat of sublevel coal mining safety.

2.4. Goaf water disaster
The main minable coal seams lie shallow in the earth and coal mining has a long history in this area. Lots of age-old goaf, small kiln, self gobs and waste lane are distributed all over the mines, and there is a lot of water. The water of age-old goaf is very concentrated and high pressure, so it is very easy to enter the mine lane through roof hydraulic conductivity crack zone and other ways, and lead to mine water disasters.

2.5. Karst collapse column water disaster
It is found that a large number of karst collapse columns in the mines and mostly distributed along the fault and this phenomenon is caused by strong runoff near the fault where karst collapse columns are development. Since the existence of karst collapse columns, mechanized mining technology can not be used in some coal mines and these karst collapse columns have changed the hydro-geologic conditions, become a major threat to mining safety.

Now, the coal mines in Hanxing mine area are further mining sublevel coal. For above stated reason, Daqing limestone water, Middle Ordovician high-pressure limestone water, goaf water and karst collapse columns are the major disaster threat. There is risk of submergence once the water burst.

3. Water control measures
Through the above analysis, water control measures are proposed for the type of water disaster of the coal mining based on "Rule of Mine Prevention and Cure Water Disaster"[5] and "Coal Mine Safety
3.1. Surface water control measures

(1) Every coal mine should carry out its hydro-geologic supplementary survey to identify surfer water features and the impact of coal mining.

(2) The gutter and river section hidden trouble existing should to carry out the work, such as plus embankment and dredging. At the same time increase the height of the wellhead or impermeable fence construction.

(3) The coal mine should backfill ground subsidence pits caused by coal mining.

(4) The coal mine should leave water-prevention pillar for the surface perennial water, according to "Buildings, water, rail and major roadway pillar leaving and under coal mining regulations"[7] (Referred to as the "Three lower regulation").

3.2. Coal roof aquifer water control measures

(1) The coal mines affected by the water of Quaternary loose rock pore aquifer should leave coal pillar for this aquifer according to "Three lower regulation".

(2) Laid drillings for detecting coal mining "three zones", in order to obtain more accurate height features of without caving zone and hydraulic conductivity fracture zone.

(3) Dewater the Damei roof sandstone water by stages.

(4) For static reserves-based Yeqing, Fuqing and Daqing limestone water, coal mines should directly dewater. When Daqing limestone water and Ordovician limestone water are hydraulically connected, coal mines should identify the supply sections and grout to intercept them, dewater to release the stress.[8-9]

3.3. Ordovician limestone aquifer water control measures

(1) Evaluate the water inrush coefficient. Take the sub-standard, sub-regional isolated mining exploration techniques and measures to mine the coal under the safe water pressure.

(2) Stress release by lowing water pressure. When the coal seam floor lacks of impermeable capacity, coal mines can release the stress of aquifer water by lowing the water pressure to reduce the water inrush coefficient.

(3) Transform the floor aquifer and reinforce the water-resisting layers[10].

3.4. Goaf water control measures

Investigate the goaf and its water filling situation by the way of first geophysical after drilling verification. For the identified or basic identified goaf water area can be set to leave water-prevention pillar, build enclosed wall, or sparse drainage by drillings by stages.

3.5. Karst collapse column water control measures

Karst collapse columns must be detected at the first pit before the coal mine extraction. In combination with ground geophysical exploration situation, delineate the collapse columns and drilling verify. After the collapse columns area and location are identified, the safe coal pillar can be set 10-15m away the collapse column area.
4. Conclusion

(1) Hanxing coal mine area is containing many types of water disasters. With the sub-level coal seams further exploitation, Daqing limestone water, Middle Ordovician high-pressure limestone water; goaf water and karst collapse column water have become the main threat to coal mining.

(2) Water control work in this coal mine area should adhere to forecast before any mining activities; and take the comprehensive management measures, such as prevent, block, sparse, row and cut. For different types of water disaster threat the corresponding water control measures are suggested.

References

[1] PIAO Changsen, ZHANG Xicheng, YIN Wancai, et al. Inundation in the North-China Type Coalfields and the Status Quo of its Protection. Geological Review 2001; (4): 406-407.
[2] ZHANG Yongqiang. Study on Mining with Water Pressure of Wannian Mine in Fengfeng Coalfield. Hebei: Shi Jia Zhuang University of Economics, 2008.
[3] ZHAO Qingbiao. Construction of Technical Guarantee System for Water Prevention and Control in Coal Mining under Safe Water Pressure of Aquifer. China Coal 2010; 36(1):98-103.
[4] YIN Huiyong, PIAO Changsen, WEI Jiuchuan, et al. Coal Mine Water Disaster and Control Countermeasures of Shandong Province. Mining Safety and Environmental Protection 2009; 36(6):79-81.
[5] State Administration of Work Safety, State Administration of Coal Mine Safety. Rule of Mine Prevention and Cure Water Disaster[M]. Beijing: Coal Industry Press, 2009:27-53.
[6] State Administration of Work Safety, State Administration of Coal Mine Safety. Coal Mine Safety Regulations. Beijing: Coal Industry Press, 2011:44-49.
[7] JIN Liansheng, MU Jinsuo. Buildings, Water, Rail and Major Roadway Pillar Leaving and Under Coal Mining Regulations. Beijing: Coal Industry Press, 2000:21-53.
[8] ZHANG Lihai, ZHANG Yecheng. Coal Mining Water Inrush Accident Control Method. China Mining Magazine 2008;(9):13-15.
[9] HU Weiyue. Coal Mine Water Disaster Control Theory and Methods. Beijing: Coal Industry Press, 2005:111-163.
[10] LI Baigui. On the Grouting Transformation of Limestone in Floor Coal Seam. West-China Exploration Engineering 2002;(6):58-60.