

## **New Technology of Preventing and Controlling Underground Water Hazard for Chinese Underground Non-coal Mining**

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**Abstract** The purpose of this article is to understand the potential water hazards in Chinese underground mining and categorize the type of those hazards, as well as to point out their dangerousness. This paper also introduced some water controlling and preventing technologies represented by Changsha Institute of Mining Research in recent years, such as ground curtain grouting, control dewatering, karst collapse control, roof curtain grouting in underground mines, flooding control. It is worth promoting application in similar mines in China.

**Keywords** mine water hazards, curtain grouting, dewatering control, Karst collapse, flooding control

### **Introduction of the mine water hazards**

Mine water hazard, which is associated with gas and coal dust explosion hazards, is one of the main safety hazards in mine construction and production process. Evidences have shown that our country suffered heavy casualties and sizable economic loss as a result of those water hazards. According to incomplete statistics, in the past 20 years there are more than 250 mines were flooded and more than 1800 miners were killed, that leads to an economic losses up to 350 billion. In recent years, an increasing amount of mineral resource consumption result in the rapidly growing numbers of mining industries, thus not only benefits the economics but also cause more frequently groundwater hazards, such as mine water inrush. According to incomplete statistics, there were 16 water inrush accidents occurred since 2003.

Mine water hazards are prominent and horrible that they always result in the massive humanity injuries and deaths, especially in non-coal mines. Such as the water accident in Gujiatai Iron Ore in 1998, 29 miners were killed due to the roof water inrush; as well as water inrush in the old workings caused 91 deaths in NanDan LaJiaPi Tin in 2002.

Water disaster is sudden, destructiveness, often leading to a large number of casualties, which irreparable loss to people's lives and property. In addition, the characteristic of water hazards also involves high degree of difficulty to rescue survives, leading to large economic losses, long mine recovery cycles and some other safety issues. Mine water disaster has become one of the major safety problem we should concern.

Affected by geologic conditions, the mining history and other objective factors , hydrogeologic conditions of mining area in our country is extremely complex. Not only the types or the size of the inrush threats, but also the severities of those accidents are rare in the world. Surface water, goaf water, alluvial water and karst water are the mine factors contributes to the potential water hazards.

### **New technologies of preventing and controlling underground water hazards in non-coal mines**

Methods of prevention and treatment of mine water are generally divided into three kinds, dredging, plugging, and avoiding. A comprehensive program in practical applications often uses a basic method and some supplementary methods. Specifically, mine water preventing should start with understanding of the hydrogeological condition. On this basis, our preventing measures should maintain the sequence that “from simple to complex” and “from surface to underground”. Measures should be taken to control the surface water when it is

possible to form a surface water inrush. underground waterproof and drainage measures should be taken for preventing underground water hazard. To ensure the safety production, the pit mainly should sparse and intercept groundwater as far as possible in the shallow. Curtain grouting should be taken under both the appropriate hydrogeologic conditions and reasonable economic and technical conditions (Wang 2002).

In recent years, in order to prevent groundwater disasters getting worse, improve the safety of mining, reduce the cost of preventing and controlling mine water and protect environment and underground water resource according to the government's policies, Changsha Institute of Mining Research Co., Ltd has developed a series of new technology of controlling underground water hazards in non-coal Mine based on the long-term development and practice of mine water control technologies and the related applications. The article briefly discussed about five aspects of the new water technologies.

### **Ground curtain grouting**

China is a large scale country. Limestone is widely distributed, mining in karst mineral deposits has to face serious problems such like the broad distribution, diversity mining difficulties, massive inrush water and other safety concerns associated with underground mining. The method of the traditional prevention and controlling of water drainage, not only expensive, but also cause problems of ground collapsing violently, pollute water and sharpen contradictions between mining and agriculture. However utilizing of underground water blocking, which controls mine water by increasing surrounding mine pressure through exploitation, has a higher probability to cause water inrush in underground mines. In order to prevent and control mine water hazards, our hydrogeological engineers had developed the mine floor curtain grouting technology. The technology is to use series of drilling grouting methods in main inlet direction. With a certain amount of pressure to push the slurry material fractured karst aquifer, the volume of cracks and cross section are reduced after consolidation, thus prevent the groundwater from entering the pit. Theoretically, curtain grouting technology can be used in all mines that are lateral recharge-based mining. It uses impermeable boundary existing in mining area as possible, blocking on the main water passage, so as to achieve a multiplier effect.

According to incomplete statistics, there are around 40 mines applied with curtain grouting technology and it is evident that mine water hazards in these mines were eliminated or controlled. The main function of curtain grouting technology is categories

- A. Inside of curtain, using the water drainage, can completely eliminate major underground water inrush accident, maintain safe production and ensure the safety of people's life and property;
- B. Investing curtain method generally requires four to five years to recover the investment, can significantly reduce mine water inflow, so as to make significant economic profits;
- C. Sharply reduce or even completely avoid karst collapse, protect mine geological environment;
- D. Protect groundwater resource within the mine, especially in regions where water shortages, meaning more prominent;

However, our past grouting curtain method also has weaknesses, such as the high engineering investment, the limited water plugging rate, the curtain holes are not targeted distributed, means of detecting intercepting capacity attenuation effect and grouting behind, which restricted the comprehensive promotion of this technology. In order to solve these problems, Changsha Institute of mining research, through experimental research and engineering in curtain of Xinqiao Pyrite Mine, curtain of Fankou Lead Zinc Mine, curtain of Daye

Dahongshan Mine and other projects, mainly adopts the new technology in the following aspects (Wang 2006).

### ***Large-scale usage of cheap grouting material***

Traditional curtain grouting invest ordinary cement as main material, thus not only the high cost and but also the poor effect of water plugging, limits promoting and application of this technology. Through the experimental study, evidences have shown that fly ash, tailings, clay, gypsum, red mud and waste or cheap material can be used as grouting material. Such as curtain in Xinqiao Pyrite Mine, Fankou Lead zinc mine, Dahongshan Mine and Zhao Jia Wan copper mine had obtained remarkable effect of the water plugging and greatly reduced the curtain engineering investment, by utilizing a large amount of clay, slag, fly ash and other waste materials.

CT of holes or ground geophysics explore water conducting structure and detecting grouting effects.

Hole ultrasonic, electromagnetic wave of CT fluoroscopy and ground electrical prospecting technology was used in Xinqiao Pyrite Mine, Dahongshan ore, Fankou Lead zinc mine respectively. These technologies not only contributes in detecting hydraulic structure and drawing up layout of grouting holes in pre-curtain works but also helps in the late curtain, which used to find the weak parts of the project, guiding layout of adding holes, and evaluate the project.

Using numerical simulation technology to guide design and dynamic guide construction of curtain.

Set up water level observation networks in mining area so as to optimize the plan and select appropriate position by comparing various solutions through numerical simulation of mine hydrogeology data. The curtain process include regular observation of water level of curtain hole in upstream and downstream, establish mathematical model of hydrogeology, timely record the change of the main water seepage. All those processes are necessary to achieve the goals of dynamic guide subsequent construction of curtain.

### ***Intelligent grouting process***

The flow rate measuring instruments, pressure measuring instruments, electric control valves, computers, printers and electric control cabinets are installed on the central control room. Systematically use the modular structure of software, can realize the intelligent grouting process.

### ***New clay pulping process***

Pulping technology of natural clay is always a difficult problem. By developing of high speed and high efficiency grinding pulp conveying system, forming a raw material crushing, transportation and pulp integration, that greatly improves the working efficiency, reduces the labor intensity of workers.

### ***Control dewatering technology***

Control dewatering technology was first put forward by the Changsha Institute of Mining Research and applied in domestic metal mines, which is a major development of traditional dewatering technology. Its main principle is based on guaranteeing the mine development and mining engineering safety, to controlling shape of pit drawdown funnel, so as to try not to row of groundwater, little discharge groundwater or late row of groundwater, to prevent

water irruption, reduce the cost of drainage, protect the drainage of groundwater resources and the control of ground subsidence. This method is mainly applicable to the deposit where hydrogeological condition is very complex and the aquifer structures have certain differences in space. It is mainly through comprehensive measures such as leading-boring exploration of water, dewatering depressurization, water level monitoring, water plugging and numerical simulation techniques to achieve.

Control dewatering technologies can be classified into three types based on the mine conditions, existence of pluralistic structure that mine aquifer in profile or aquifer (belt) in the local area whether has the relative independence, whether there is relatively impermeable layer between deposit and aquifer or the deposit is thick and massive without water. To deal with those three conditions, Single layer (lower layer) sparse dry, Section dewatering or buck sparse dry can be used respectively.

The successful examples with investing this control dewatering technology are listed here. Such as Jinling iron has installed a comprehensive lower sparse dry that “aquifer of lower dewatering, mining with pressure, appropriate shrinkage, supplemented by interception”. It reduced the inflow of water at the same time, realized safety mining (Haipin 2004); The method combined dewatering with plugging in each section, was used by Anqing copper mine no. 1 ore body and achieved the goals of prevention sudden flooding wells, significantly reduced displacement and controlled ground subsidence or settlement purposes. Xinwen Coal Mine adopts the “prevention first, mining with pressure, proper drainage supplement with blocking, and achieved good effect of prevention and control of water”.

### ***Technology of ground subsidence control***

Karst ground collapse is a common geological disasters caused by karst water drainage in mines. This ground collapse is always a horrible threat to people who has been working in the mine. Using curtain grouting cut-off or grouting in underground water point scheme in certain mines, can control the subsidence range and reduce the frequency of occurrence of collapse or the scale. If this method cannot be performed, it can only control subsidence area at the ground, but the technology has always been a problem and often can't solve the problem of recurrent collapse fundamentally. In recent years, Changsha Institute of mining research has been studying through onsite research at the anqing copper mine, fankou lead-zinc mine, xiagao iron mine and other similar mine suffered Karst ground collapse and had summarized the unique method of preventing karst collapse and had figured out the whole set of collapse prevention and control measures (Wang 2001).

- (1) integrated control collapse
- (2) closed hole of collapse
- (3) backfill and grouting
- (4) static pressure grouting for collapse
- (5) pre-treatment of hidden

### ***Technique of curtain grouting beside the ore body***

Curtain grouting beside the ore body, as a new technique for watery mines, was put into practice in our country. It has a high difficulty level and always requires professional and technical supports. It was invented and successfully put into practice by Changsha institute of mining. It is an extension of ground the curtain grouting technique, whose main principle is to use a series of drilling in orebody, injecting slurry to form water-resisting layer of artificial roof and cut off the supply channel of groundwater for mine. The technology has the advantages in reducing drainage cost, protecting of groundwater resources, protecting the

geological environment and other significant aspects, and it worth the promotion. The technology has conditions for application, such as: the orebody is relatively concentrated; top (bottom) layer is a rich aquifer, water inflow is large, as if adopt drainage method is easy to cause environmental problems such as ground subsidence, groundwater resources depletion, even make the mine under the heavy burden and unsustainable. Yezhuang iron mine is the first mine successful invested curtain grouting beside of ore body technology. The project is almost complet, and the water plugging rate as high as 98%, plugging effect is quite good. Currently the mine has been excavating the roof pillars, it is evident that a very good profit were obtained from the project.

### ***New technology of grouting treatment for the deep well's flooding***

Generally, strong platoon drainage method and grouting plugging water method are used to deal with deep well's flooded. This article only discusses grouting water plugging treatment method. Grouting plugging water is mainly divided into the underwater concrete bottom sealing method, underwater holes grouting bottom sealing method, the ground local heavy curtain grouting method and the directional hole grouting method. These methods mainly based on the well depth, buried depth and hydrogeology, borehole facilities, project time requirements to comprehensive determined. Underwater concrete bottom sealing method is relatively simple; the ground local heavy curtain grouting method is similar to the ground curtain grouting technique. The following is the briefly illustrate of new technology of underwater holes grouting bottom sealing method and the directional hole grouting method respectively.

#### **(1) the underwater holes grouting bottom sealing method**

Underwater holes grouting bottom sealing method is first of all to throw in stones to the flooded mine (Shaft, slope, drift), and then grouting back. Then we can isolate the inrush water sources and restoring the flooded mine. If the shaft is deep and well facilities is complex, water inrush point is at the bottom of the wellbore or near the horse head door entry, then we should give priority to adopt this technology. The main technical points are as follows:

- a) graphical method to confirm the water bursting layer's static water level
- b) confirm the security thickness of the sealing layer
- c) to develop dump bucket ballast
- d) irrigation end-sealing grouting method
- e) using graphical and sampling method to judgment sealing effect comprehensively

#### **(2) The directional hole grouting method**

The directional hole grouting method is in view of the inrush part to adopts the technology of the directional hole directly plugging water bursting point, and then drainage to restore flooded mine. If the water inrush point is inside the deep mine stopped or within the drift away from the horse head, then we should give priority to adopt this technology. The main technical points are as follows:

- a) select of water inrush point's location
- b) water plugging scheme design
- c) directional drilling technology
- d) dynamic water grouting water plugging technology

### **Conclusions**

Mine with Karst limestone, especially the water-rich mines, tend to show a variety of forms of water disasters. Look from the development trend of mine water preventing and

controlling at domestic and foreign, we should prevent and control the hazards comprehensively. When the economic and technological conditions are appropriate, given priority to preventing and retreating water measures as possible with curtain grouting water plugging, hence to eliminate the underground water inrush, protect groundwater resources and control surface collapse. If it is difficult to adopt the curtain grouting technique, then we can adjust measures under local conditions, using controlled drainage, underground orebody ceiling curtain, subsidence control and other appropriate water technologies, to focus on the main hydrogeological and engineering geological problems in mine.

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