WEP Warwick Evans Publishing

International Journal of Natural Resources and Environmental Studies

ISSN: 3006-2012 (Print), ISSN: 3006-0834 (Online) | Volume 8, Number 3, Year 2026
DOI: https://doi.org/10.62051/ijnres.v8n3.14
Journal homepage: https://wepub.org/index.php/IJNRES/index

Research on Prediction and Prevention Technology of Mine Water Disaster

Runmin Wang[1, *], Yudong Fang[2], Siyi Liu[1]

[1]School of Resources and Environment, Henan Polytechnic University, Jiaozuo 454000, China;
[2]School of Energy Science and Engineering, Henan Polytechnic University, Jiaozuo 454000, China
*Corresponding Author: Runmin Wang

ABSTRACT

Mine water disaster is a common safety hazard in the process of coal mining, which poses a major threat to the life safety of miners and coal mine production. Major safety and environmental problems in the process of mining. With the continuous increase of mining depth, the difficulty of mine water prevention and control is also increasing. This paper first expounds the types and hazards of mine water disaster and the current situation, problems and development trend of mine water prevention and control, and then analyzes in detail the common methods of water disaster prediction, including geological exploration, hydrogeological investigation, hydrological simulation, remote sensing technology, etc., and compares the advantages and disadvantages of each method. Finally, the measures of mine water disaster prevention and control are discussed, including mining design, hydrological control, precipitation and drainage, water plugging and water control, etc., and the application effect of prevention and control measures is analyzed with specific cases.

KEYWORDS

Mine water disaster; Prevention and control technology; Hydrogeology; Prediction; prevention.

1. INTRODUCTION

As an important energy resource, coal plays an important role in the development of national economy. Mine water is an inevitable factor in the process of mine mining. However, the occurrence conditions of coal resources in China are complex and the groundwater is abundant. Mine water damage has always been a major hidden danger in coal mine safety production, which poses a major threat to mine safety production and ecological environment. Mine water prevention and control work is an important part of ensuring mine safety production, preventing water disaster accidents and protecting the ecological environment of the mining area. In recent years, with the increasing depth of coal mining, the geological conditions are more complicated, and the frequency and degree of water damage are also on the rise, causing significant losses to the lives of miners and coal mine production. Therefore, it is of great practical significance to strengthen the prediction and prevention of mine water disasters.

2. TYPES OF MINE WATER HAZARDS AND THEIR CAUSES

2.1. Types and hazards of mine water disaster

Mine water disaster refers to the phenomenon that groundwater or surface water enters the mine and causes harm to the safe production of the mine. According to the source of water disaster and the

degree of harm, mine water disaster can be divided into the following types[1]: 1 Water inrush: a sudden influx of groundwater or surface water into the mine, causing serious consequences such as underground casualties, equipment damage, and working face inundation. 2 Gushing water: groundwater or surface water continues to flow into the mine, causing underground water accumulation, affecting production progress and safety. 3 Water accumulation: in the process of mine mining, due to poor drainage or increased precipitation, resulting in underground water accumulation, affecting production operations. 4 Flooding: Due to water inrush or water gushing, the mine is flooded, resulting in production stagnation, and even permanent damage.

The harm of mine water disaster to coal mine production is mainly reflected in the following aspects: 1 Safety hazard: Water inrush, water gushing and other water disasters will lead to underground casualties and cause major safety accidents. 2 Production loss water damage will cause production stoppage, equipment damage, affect the production schedule and output. 3 Environmental pollution: Mine water damage will lead to water pollution in the mining area and affect the surrounding ecological environment. 4 Economic losses: Mine water damage will cause huge economic losses, including casualties compensation, equipment maintenance costs, production losses and so on.

2.2. Causes of mine water disaster

2.2.1. Technical factors

In deep coal seam mining, there are a series of technical factors that may lead to mine water disaster. First of all, the fracture or deformation of the coal seam floor and roof may be encountered during the mining process, resulting in the formation of mine fissures. These fissures may be connected to the groundwater body, resulting in the influx of groundwater into the mine, forming mine water inflow. Secondly, in the process of coal seam mining, the extraction of coal and gas will lead to the change of coal seam pressure, which will affect the flow of water in coal seam. Improper operation of gas extraction may lead to mine water migration and water gushing. In addition, unreasonable drainage and treatment measures during the construction process, such as blockage of drainage pipes or failure of drainage systems, may also lead to mine water hazards.

2.2.2. Geological conditions factors

Geological conditions play an important role in mine water damage. The groundwater system in coal seam mining area is one of the main sources of mine water damage. When there is a high aquifer below or around the coal seam, groundwater may penetrate into the coal seam through cracks, causing mine water inflow. Geological factors such as the change of groundwater pressure, the rise of water level or the destruction of groundwater pressure bearing layer may also cause mine water damage. In addition, the activity and deformation of geological structures, such as the sliding of faults and the dislocation between coal and roof, may also lead to the movement of groundwater and the occurrence of mine water disasters.

2.2.3. Coal mine water filling channel

Mine water filling channel is the key content of mine water disaster. The so-called coal mine water filling channel generally refers to the water diversion channel between the mine water source and the mine working face. The formation of mine water filling channel is mainly affected by two factors. One is caused by natural factors. That is, the mine channel is naturally formed without human intervention. Another is caused by human factors. That is, due to the influence of man-made mine production activities, the water diversion channel between the mine water source and the mine working face was accidentally opened. The former is the basis of the latter, and the emergence of the latter will further strengthen the water conductivity of the former. Such as mining

2.2.4. The color is more gorgeous

In the development of traditional embroidery, many patterns have very gorgeous colors. This gorgeous color is extremely recognizable, which makes the whole embroidery artistry by going up one flight of stairs. At the same time, in the process of creating embroidery works, people should also show local famous folk paintings through color matching. Common TINT, there are red with green, red with black and red with yellow. Very traditional color matching has a strong connection with the cultural characteristics of our country. Moreover, some folk embroidery patterns will also use different treatment methods such as retrograde halo and color halo to adjust the color pertinently, so that the artistic appeal of embroidery can be further improved

3. PREDICTION AND DETECTION OF MINE WATER DISASTER

3.1. Prediction of mine water disaster

In order to effectively prevent and control mine water disasters, it is necessary to accurately predict the possibility and extent of water disasters. At present, the commonly used water disaster prediction methods mainly include the following[2]:

1 Geological exploration: Geological exploration is the basic work of mine water disaster prediction, including geological mapping, drilling sampling, core analysis and so on. Through geological exploration, we can understand the important information of geological structure, lithology, aquifer distribution and hydrogeological conditions in the mining area, and provide basic data for water disaster prediction.

2 Hydrogeological investigation: Hydrogeological investigation is to investigate and study the groundwater in the mining area, to understand the groundwater burial depth, water quantity, water quality, flow direction, etc., and to provide hydrogeological parameters for water disaster prediction. Hydrogeological survey methods mainly include well location layout, water level observation, water sample analysis, water chemical analysis and so on.

3 Hydrological simulation: Hydrological simulation is the use of mathematical models to simulate the law of groundwater flow and predict the possibility and extent of water damage. The hydrological simulation method needs to establish a groundwater flow model based on geological exploration and hydrogeological survey data, and conduct numerical simulation calculations.

4 Remote sensing technology: Remote sensing technology can quickly and efficiently obtain the surface information of the mining area and provide auxiliary data for water disaster prediction. Remote sensing technology can identify groundwater outcrops, surface water distribution and other information, and provide reference for hydrogeological survey.

5 Other prediction methods: In addition to the above methods, there are other water hazard prediction methods, such as:

Sound wave detection: Using the difference of sound wave propagation velocity in different media, the buried depth of groundwater and the characteristics of water body are detected.

Electromagnetic detection: Using the propagation characteristics of electromagnetic waves in different media to detect groundwater distribution and water characteristics.

Geochemical detection: using the change of chemical composition of groundwater to predict the possibility of water damage.

3.2. Detection of mine water disaster

1 Underground DC detection method: Underground DC detection method is a commonly used deep coal seam mine water disaster detection technology. This method is based on the difference in the

conductivity of the current through the underground medium, and the electrode is arranged in the underground to apply a DC electric field to measure the distribution and flow of the groundwater body. In the downhole DC detection, the electrodes are usually divided into positive and negative electrodes. The DC voltage is applied between the electrodes to measure the distribution and flow of the current. According to the change and distribution of current, the location, flow direction and water level change of groundwater can be judged, so as to predict and monitor the occurrence and evolution trend of mine water disaster. The underground direct current detection method has the advantages of non-invasive, high sensitivity and real-time performance, and is widely used in the detection and early warning of water disasters in deep coal seams.

2 Transient electromagnetic detection method: Transient electromagnetic detection method is a coal mine water disaster detection technology based on the principle of electromagnetic induction. This method uses the induction effect of transient electromagnetic field to generate transient electromagnetic field by sending short pulse current underground, and then determines the existence and distribution of groundwater by measuring the received electromagnetic signal. Transient electromagnetic detection method can detect the conductivity difference of groundwater, so as to determine the location and properties of water. Through the analysis and interpretation of electromagnetic signals, the information of groundwater can be obtained, including water level, flow velocity and the relationship between water body and surrounding geological media. The transient electromagnetic detection method has the advantages of high precision, fast response and large-scale detection, which is suitable for mine water disaster monitoring under complex geological conditions.

3 Audio electro-permeation perspective detection method: Audio electro-permeation perspective detection method is a kind of deep coal seam mine water disaster detection technology using acoustic wave propagation characteristics. This method judges the existence and distribution of groundwater by sending acoustic signals in the well and using the characteristics of attenuation and reflection of water when acoustic waves propagate in underground media. By measuring the propagation speed, attenuation degree and reflection of sound waves, the position, thickness and nature of water body can be determined. By analyzing the characteristics of the acoustic signal, the water level, permeability and the relationship with the surrounding rock of the groundwater can be inferred. Audio electroporation perspective detection method has the advantages of simple operation and intuitive data interpretation, which is suitable for mine water disaster detection in the case of shallow water or underground cracks. In addition, this method can also be combined with other detection techniques to improve the accuracy and reliability of water hazard detection.

4. PROPHYLACTICO-THERAPEUTIC MEASURES

4.1. Prophylactico-therapeutic measures

4.1.1. Mining design

In the design stage of mine mining, it is necessary to fully consider the hydrogeological conditions of the mining area, formulate a scientific and reasonable mining plan, and take the following measures[3]: 1 Avoid aquifers: Avoid aquifers as much as possible, or take water-proof measures to prevent groundwater from entering the mine. 2 Reasonable selection of mining method: According to the hydrogeological conditions of the mining area, the appropriate mining method is selected, for example, the method of setting protective layer or water-proof coal pillar is adopted[4]. 3 Reasonably determine the mining sequence: scientifically formulate the mining sequence, and try to avoid damage to the aquifer. 4 Set waterproof coal (rock) pillar. In the process of mine mining, some areas are very vulnerable to the threat of water filling. Therefore, in order to reduce this threat, it is necessary to set a certain width of coal (rock) pillars near the area with greater threat in combination with the actual mining situation. Then with the help of coal pillars, the mine water barrier is completed. This coal (rock) pillar is also called waterproof coal (rock) pillar. In the actual process of retaining water-proof

coal (rock) pillars, many influencing factors need to be considered, such as the water pressure of the separated water source and the water content. At the same time, it should also take into account the actual thickness of the coal seam, accurately grasp the size of the roadway, and understand the degree of damage to the surrounding rock. In addition, in order to ensure the rationality of the setting of the water-proof coal (rock) column, the roof caving after mining should also be considered. Combining the above factors, the waterproof effect of the water-proof coal (rock) column can be better exerted.

4.1.2. Hydrological control

Hydrological control refers to the control of groundwater flow through artificial measures to prevent groundwater from flowing into the mine. Commonly used hydrological control methods include[5]: Water exploration and drainage: In the actual water discharge treatment, it is necessary to combine the actual situation, strictly follow the principle of ' explore if you have doubts, explore first and then dig ', and carry out the following series of water prevention and control measures: First, the specific location of these water bodies should be ascertained ; subsequently, a comprehensive assessment of the location of the water body was carried out. On this basis, corresponding measures were taken to release the water smoothly.

Precipitation: by pumping or other methods to reduce the groundwater level, reduce water inflow.

Water shutoff: to prevent groundwater from flowing into the mine by blocking water sources or water channels.

Drainage: by diverting the flow of groundwater, the groundwater is led to a safe area to prevent it from entering the mine.

4.2. Challenges faced by mine water prevention and control

4.2.1. The mining depth is increasing[6].

With the continuous deepening of mineral resources exploitation, the mining depth is increasing, the groundwater pressure is increasing, and the water inflow of mine water is also increasing, which brings great challenges to the prevention and control of mine water.

4.2.2. Complex geological structure[6].

The geological structure of the mining area is complex, and the geological phenomena such as fracture, fold and karst are widespread, which leads to the complex flow law of groundwater and brings difficulties to the prevention and control of mine water.

4.2.3. Deterioration of mine water quality

Affected by human activities, the water quality of mine water is gradually deteriorating, containing a large number of harmful substances such as heavy metals and acidic substances, causing pollution to the environment and bringing new challenges to mine water treatment.

4.2.4. Lack of innovation in prevention and control technology

The existing mine water prevention and control technology generally has limitations, which can not effectively solve the problem of mine water prevention and control in some complex situations. It is necessary to develop new prevention and control technologies to meet new challenges.

4.3. Innovating the decorative mode of traditional embroidery

Traditional embroidery has developed for thousands of years. Has its own characteristics. The very fixed pattern is accepted by more and more young people. Therefore, in the process of fashion design, there is a monotonous problem, and the decorative pattern is fixed, so the overall variability is less. Clothing has a very strong personal characteristics, which will produce too vulgar when designing, and the effect is also very inflexible, which cannot meet people's aesthetic needs. In fashion design,

according to the degree of people's love[5], taking into account the diversity of fashion design changes. When designing, we must conform to the concept of human development, and innovate the decoration mode because of the change of human aesthetic taste. Therefore, the traditional form of expression of scientific facilities, the location of its decoration and the mode of transformation, so that it has a modern design atmosphere. Therefore, in the process of modern clothing development, designers need to put traditional embroidery patterns into more diverse parts of clothing[7]. For example, shoulders and waist can effectively break through the traditional mindset and give people a refreshing feeling. For designers, when using embroidery, they should also deal with the traditional embroidery art scientifically, and further optimize the effect of patterns according to the current consumers' needs and fashion frontiers, so that the overall decoration and color matching are more fashionable. For example, in some haute couture conferences, many design products will use bead embroidery, plate gold and other three-dimensional embroidery to decorate the whole clothing, which makes the three-dimensional effect of the whole clothing stronger and elegant.

5. DEVELOPMENT TREND OF MINE WATER PREVENTION AND CONTROL TECHNOLOGY

5.1. Intelligentization and informatization[8]

In the future, mine water prevention and control technology will develop in the direction of intelligence, using artificial intelligence, Internet of things, big data and other technologies to realize the automation, intelligence and fine management of mine water prevention and control. An intelligent monitoring and early warning system for mine water based on Internet of things, artificial intelligence and cloud computing technology is established to realize real-time monitoring and early warning of mine water level, water quality, water quantity and other parameters, and to improve the intelligent level of mine water prevention and control. The mine water prevention and control expert system is developed, and the mine water prevention and control measures are optimized and decided by using big data analysis and machine learning technology.

5.2. New materials and new technologies

Use high-performance waterproof materials, such as nano-waterproof materials, polymer waterproof materials, etc., to improve the water seal effect.

Develop new water level control technologies, such as ultrasonic water level control technology, electromagnetic water level control technology, etc., to improve the accuracy and efficiency of water level control. The use of new underground engineering construction technologies, such as shield tunneling technology, directional drilling technology, etc., to improve the construction efficiency and quality of waterproof and drainage projects.

5.3. The concept of green environmental protection

In the future, mine water prevention and control technology will pay more attention to green environmental protection, develop energy-saving and efficient prevention and control technology, reduce environmental pollution, and achieve sustainable development. Using water-saving technologies, such as recycling mine water, precipitation reuse, etc., to reduce water waste. Develop green water treatment technologies, such as biological treatment technology, membrane separation technology, etc., to reduce the impact of mine water discharge on the environment.

5.4. Comprehensive management development

In the future, mine water prevention and control technology will pay more attention to comprehensive management, organically combine various prevention and control technologies, form a complete prevention and control system, and improve the efficiency and effect of prevention and control. Making plans: The emergency plan for water inrush accidents has been formulated to improve the ability to respond to emergencies.

6. CONCLUSION

Mine water disaster is a major hidden danger in coal mine safety production. Mine water prevention and control is an important link in mine safety production and ecological environment protection. With the continuous increase of mining depth and the continuous improvement of environmental protection requirements, mine water prevention and control work is facing new challenges. It is very important to do a good job in mine water disaster prediction and prevention and control work to ensure the safety of miners ' lives and ensure the safety of coal mine production. In the future, mine water prevention and control technology will continue to develop and innovate to meet the needs of mining and environmental protection requirements, and ensure mine safety production and ecological environment safety. In order to improve the prediction accuracy and reliability, a variety of methods should be adopted for comprehensive analysis of mine water disaster prediction. The prevention and control of mine water damage should start from the aspects of mining design, hydrological control, precipitation and drainage, water plugging and water control, and take a number of measures to effectively control water damage. The research and application of mine water disaster prevention and control technology should be strengthened, and new technologies and methods should be developed to improve the level of water disaster prevention and control.

REFERENCES

[1] Chen Zongfa. Coal mine water disaster prediction and prevention. Beijing: Science Press, 2010.

[2] Research progress of mine water prevention and control technology [J].Mine safety and environmental protection, 2023,50 (01): 1-7.

[3] Di Xiangyu.Research and application of advanced water exploration technical measures in shaft construction [J].Mining Engineering, 2020,18 (05): 19-21.

[4] Gao Hu. Research and practice of water prevention and control in fully mechanized caving face with extremely complex geological conditions in Binchang mining area [J].China Coal Industry, 2019, (10): 62-63.

[5] Hao Junfeng. Discussion on the influence and function of mine geological structure change on hydrogeological management [J].China Petroleum and Chemical Industry Standards and Quality, 2020,40 (05): 71-72.

[6] Li Xuexin. Coal mine water prevention and control technology application research [J].Shanxi Chemical Industry, 2023,43 (12): 175-176.DOI: 10.16525 / j.cnki.cn14-1109 / tq.2023.12.070.

[7] Zhang Lei, Yu Kewei. Causes and prevention technology of mine water disaster in deep coal seam mining [J]. Shaanxi Coal, 2024,43 (06): 153-156.DOI: 10.20120 / j.cnki.issn.1671-749x.2024.0630.

[8] Zhao Yongzhong, Zhang Hu, Liu Hui. Analysis and implementation of goaf water prevention and control technology in coal mine [J]. Jiangxi Coal Science and Technology, 2024, (02): 119-121.