The Water-disaster Characteristic of Coal Mine in Shandong Province and the Research on Prevention and Control Countermeasures

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Abstract

The key to prevent coal mine water disaster is finding out the "three elements" which is separately named source, channel and strength. Only by figuring out the "three elements", can the coal mine water-disaster prevention and control work achieve its target. Through analyzing the inrush source, influence area and gushing channel, deeply understanding the current situation of coal mine water-disaster in Shandong province, this article explores the basic characteristics of the coal mine water-disaster, points out the main existing problems in the work of prevention and control of water-disaster. Also it puts forward the countermeasures of prevention and control of water-disaster and its application instance.

Keywords: Shandong province, water disaster, source, characteristic, prevention and control.

Shandong, with a long mining history, is one of the largest coal resources province in our country, coal is the important basic energy in Shandong province. Coalfield geological structure and hydro geological condition of Shandong are relatively complex. According to the statistics, the complex and extremely complex hydrogeology type coal mine in Shandong province accounted for more than 24% of all kinds of registered coal mines. All kinds of water disasters seriously threaten the development and utilization of coal resources (figure 1, figure 2). With the increase of mining depth and mining area, the threat to mine safety production is increased, among which, the water damage problem is particularly prominent. According to the statistics of Shandong coal industry bureau, among

the coal mine of whole province, there are 25 mines threatened by the surface water disaster, 29 mines threatened by the old empty water disasters, 7 mines threatened by the overburden water disasters, 30 mines threatened by the bottom pressure water disasters, 18 mines threatened by the adjacent mines and closed mine water disasters, 6 mines with the upper limit of mining working face increasing threatened by water disasters; 8 mines threatened by the connected mine water disasters. In recent years, coal mine water hazards happen from time to time in Shandong province, prevention and control of basic water management is relatively weak, hydrogeological conditions of mining working face should be find out further more, drain measures still need complements. The key to prevent coal mine water-disaster is finding out the "three elements" named source, channel and strength. Only by figuring out the "three elements", can the coal mine water-disaster prevention and control work achieve its target.

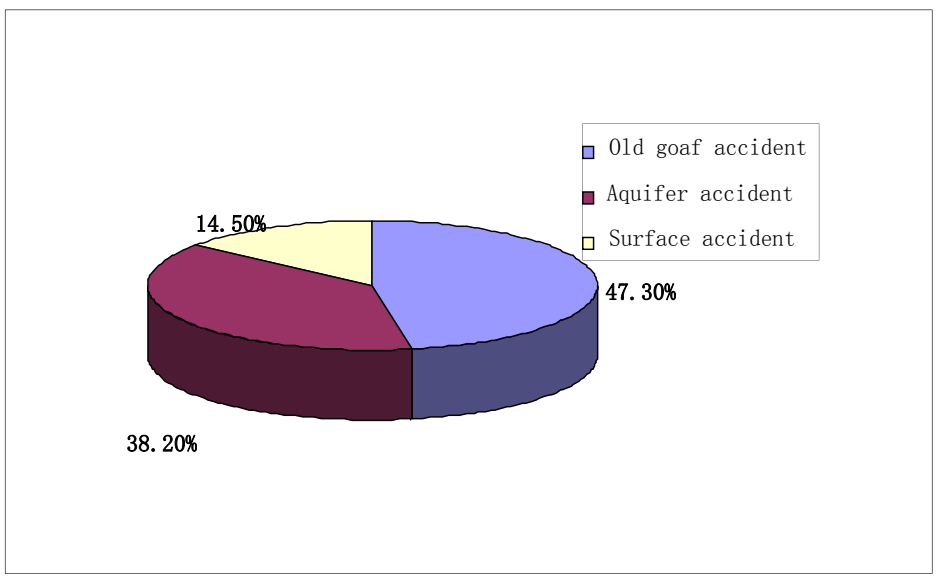

Fig 1: Statistics of catastrophic water accident in national key coal mines (1949~2004)

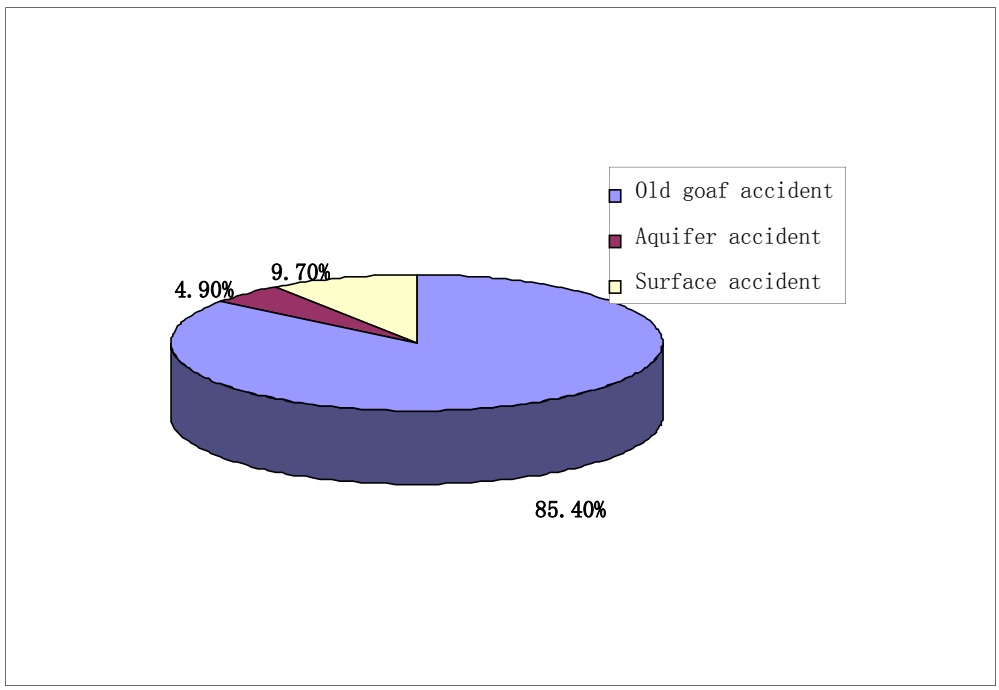

Fig 2: Statistics of catastrophic water accident in local coal mines (1949~2004)

1 Analysis of coal mine water-inrush condition in Shandong province

There are two sufficient conditions required to coal mine water inrush: the water filling source and water channels[1]. Sources of Shandong coal mine threatened by water disasters mainly include: surface water, goaf water, old gob water, Quaternary loose bed water, Paleogene sandy gravel water, Jurassic sandstone (commonly known as "red layer") water, Shanxi Formation sandstone water, Taiyuan Formation thin limestone water, Ordovician limestone water, etc. Water channels can be divided into natural and artificial channels.

1.1 Water-disaster type and influenced area

1.1.1 Water-disaster of surface and precipitation

Surface drainage is very developing in Shandong, average density of natural rivers is above 0.7 km/km2, length of the trunk stream with 50 km above has more than 1000. Water of the surface body near the mine together with the top of the mining area develops to being disaster by loose layer, surface subsidence area, tectonic fracture zones, the mined areas and wellhead collapsing into the roadway. Especially when the coal seam buried shallow, with thinner Quaternary overburden, shallow karst developed, the mine is easily supplied by atmospheric precipitation and surface water, not easy

to drainage. When encountering heavy rain and the flood, serious flooding wells accident happens. For example, Longshan mine which is located in Linyi City submergenced due to floods, causing 59 deaths in 1993. In "8.17"accident, 172 people in Huayuan mine were dead. At present, the mining area under the threat of surface water and precipitation of Shandong Province mainly include: Zibo, Zhangqiu, Tengzhou, Xinwen, etc.

1.1.2 Water-disaster of Quaternary loose layer

Such water-disasters are mainly distributed in the coal seam outcrop which is directly located in the sandstone layer under the Quaternary, with large thickness of the overlying coal seam and rich water or thin layer of Quaternary loose with unreliable wind oxidized zone of waterproof coal column. Once the coal seam mining fissure belt reaches to bottom Quaternary group, it is prone to collapse of water and sand, causing flooded surface or flooded wells whose degree of damage is larger. The mining areas which are affected by the Quaternary loose bed water mainly include: Linyi, Tengzhou, Jining, Zhangqiu, Taozao, etc.

1.1.3Water-disaster of Paleogene sandy gravel, Jurassic sandstone

These aquifers can be directly supplied by surface water or Quaternary diving water which belongs to the outcrop area or the sub crop area of Quaternary water.[2] Coal mines in Shandong province affected by the damage of Paleogene, Jurassic water are less. But it is a big threat to coal mine production, especially when the location is in the areas with more developing conglomerate and rich water, or in special geological areas, existing small space between upper minable seam and its conglomerate water body, such as the forth and sixth layer of Huafeng coal mine which is under serious threat of Paleogene sandy gravel water. The influence of such water-disasters area mainly include: Baodian mine in Yanzhou coal, Huafeng mine in Xinwen coal and Beixulou, Tianchen, Xinan mine in Tengzhou coal, etc.

1.1.4 Water-disaster of Shanxi Formation sandstone

Shanxi Formation sandstone is the main aquifer in Shandong Province's coal mines. Shanxi Formation sandstone is fracture aquifer; the water is weaker overall and in homogeneity, not easy to accept supplies, usually attaching small threat to the safety of mine production aside from the Xinwen, Jining, Tengzhou mining areas. A larger number of mines in Shandong Province are affected by the Shanxi Formation sandstone water-disaster, mainly distributing in the area which has a large thickness layer in the roof and floor sandstone, with

developing tectonic fissures and rich water, such as: Xinwen, Jining, Feicheng, Tengzhou, Zhangqiu, Ningyang and Taozao mines, etc.

1.1.5 Water-disaster of Taiyuan Formation thin limestone

Taiyuan Formation coal mines in all the mining areas of Shandong have the main coal layers, therefore the scope influenced by Taiyuan Formation thin limestone water is large. The main developing Taiyuan Formation thin limestone in Shandong province is mixed between several minable seam, relatively close from the coal seam, and karst fissure is developing, bottom Taiyuan group and Benxi group limestone are the main aquifers which threaten the coal mine safety production. The coal mines under threat of Taiyuan Formation thin limestone water-disaster in Shandong province are mainly distributed in west areas of Shandong, with developing karst, such as: Feicheng mining area, Zhangqiu mining area, Ningyang mining area, Tengzhou mining area and Taozao mining area, etc.

1.1.6 Water-disaster of Ordovician limestone

Ordovician limestone distribution range is wide, with good water supplying, rich water content, high water pressure. Ordovician limestone water is an important water disaster of coal mine in Shandong. When the confined aquifer water pressure of Ordovician is higher, owing to water-resisting layer broken, or the coal bed mining disturbance, or affected by the structure, the Ordovician karst water will breakthrough water-resisting layer, go into the pit and cause water inrush under the effect of high head pressure [3]. The Ordovician karst water is usually under high pressure, and often breakthroughs the fault, the collapse column or upper part of the tectonic fissures and makes hydraulic contact with Taiyuan group of thin-layer limestone aquifer [2].Most coal mines in Shandong province are in the mining process of the next group, Adding that the water-resisting layer is thinner, the coal mine is easily threatened by the bottom Ordovician limestone water. The influencing scope is large, with high degree of threatening .Affected by such damage areas mainly include: Feicheng, Zhangqiu, Tengzhou, Xinwen, Zibo, Yanzhou, Jining, Laiwu mining area, etc.

1.1.7 Water-disaster of goaf and old gob

The history of many mines in Shandong province of coal mining is long, so many of them make a lot of different degrees of mining area of goaf , old gob and the ancient mining area with water. The goaf water which threatens coal mining mainly displays in the threat of goaf water on the level to the level, adjacent layer goaf water shallow to deep,

neighboring goaf water in the mining areas. The disaster of the goaf water and the old gob water come suddenly and ferociously .What makes matters worse is it can cause serious casualties and flood wells accident. Various types of coal mines of Shandong are affected by such damage extensively, especially in the long mining history, the goaf area, the old gob area. The old mining area with big and small mine doping is affected worst such as: Zibo, Xinwen, Tengzhou, Taozao, Jining, Zhangqiu, Laiwu mining area, etc.

1.2 Gushing water channels

1.2.1Natural channels

Only when a channel grows with the various types of detrimental water source, can water inflow or water inrush come into being. If the channel has no connection with detrimental water source, as the fault, the water inflow or water inrush would not be appeared. The channels can cause coal mining water inrush or coal mining water inflow which are usually considered as gushing water channels, which generally can be divided into natural gushing water channel and artificial gushing water channel.

Natural channel mainly refers to the rock gap and structure pore. Rock gap mainly includes pore, fracture, and solution crack. Pores are made up of accumulation from mineral or clastic particles [4], usually exists in loose sediment, the permeable performance depends on the degree of pore size, shape, sorting and arrangement, etc. when it is exposed, mining working face presents water seepage, water trickling or water gushing and with more water points, less water yield, slow flow velocity which leads to the water inrush threat becoming smaller. Fracture channels mainly exist in hard rocks, weathering zone and structure fractured zone. Many factors decide the water permeability, such as pores, density, filling and connectedness. Soluble rock strata suffer corrosion can become rock gap, which is defined strata solution crack. With a low filling rate the karst is easy to connect, and then gushing water channels come into being. Once inrushing, the water pressure is very high and the velocity is very fast. That would lead to serious damages. Soluble rocks in Shandong Province has a certain distribution, Zaozhuang, Jining, Zibo, Feicheng, Laiwu, Weifang, there are other areas of Ordovician and Cambrian carbonate rocks.

Pore structure is due to tectonic stress undermines the integrity of the rock, creating tensile, shear, pressure, tensile twisting, twisting and other fracture pressure, increasing the permeability of the rock, mainly divided into impermeable fault zone and

permeable fault zone. Most of impermeable fault zone are attached with pressure or pressure-shear fracture, few with tensile or shear fracture and high degree of fault cementation, good filling. After coal mining, under the ground pressure and other factors, it will lead to water permeable. Permeable fault zone are mostly with tensile and tensile twisting fracture characteristics. As for low degree of cementation on both sides of the rock and limited moisture, it is easy to dewatering. However, when its side with other strong aquifer or surface water hydraulic closely linked, the water irruption quantity is very high; water is stable, hard to dewatering. Such faults are considered as the main channel of mine water inrush. On August 17th, 2010, four faults in a Shandong mine working face 8602 within 100m range communication Ordovician limestone water, causing the water gushing.

1.2.2Artificial channels

Artificial channels mainly refer to subsidence which is made by drilling exploration and mine subsidence, mine pump, long term drainage.

Because of the various explorations drill holes are not closed or with poor sealed quality, these holes become stronger water channels through aquifers and surface. As for low drainage capacity mines, artificial channels may cause mine inundation accident, for example, as a result ,Hutian coal mine happened 7 times of water inrushing and flooded wells three times. When mining, the overburden strata begin to move. From the bottom to the up, the overburden formed caving zone, water flowing fractured zone and bending zone. When caving fracture communicates strong aquifers or surface water, water damage is prone to taking place, such as the Huafeng coal mine accident of conglomerate water influxing workplace repeatedly, which took place because of small pitch between coal and aquifer when the former mining group was mined. Long-term mine drainage pumping makes groundwater levels decline and mine aquifer structure changed dramatically, karst channel connectivity increase. So the water level drops and a funnel comes into being and causing collapse. Then much surface water comes into the mine, causing serious consequences.

2. Two basic characteristics of coal mine water-disaster in Shandong province

Coal mine water-disaster in Shandong province basically has the following characteristics:

2.1Mine water source is more extensive

Considering the common roof and floor water source, surface water, goaf

water, old gob water, Quaternary loose bed water, Paleogene sandy gravel water, Jurassic sandstone water, Shanxi Formation sandstone water, generally exist in coal mine area of Shandong province, but the difference in different degree of threat to coal mining area is larger, even in the same mining area, there exist certain differences.

2.2 Influence range is wide; multiple mining areas at the same time are facing the threat of a variety of water disasters

Talking about the water disasters influence scope, Zibo, Linyi, Xinwen, Feicheng, Yanzhou, Tengzhou, chapter grave, Jining, Ningyang, Taozao, Longkou mining areas are affected by one or more of water disasters, such as chapter grave, Tengzhou, Xinwen mining area, at the same time by surface water, the Quaternary loose bed, the Ordovician limestone water, goaf water, Shanxi sandstone water.

2.3 Main damage types are outstanding

Goaf water and bottom Ordovician limestone water are the main damage types of coal mine in Shandong province. There exist abandoned old kiln and empty area in Xinwen, Zaozhuang, Zibo mining. These old kilns, dotted with goaf water in mining area, form a serious threat to coal mine safety in production. For example, on June 28, 2011, in Zibo Zichuan area, six people were killed, which is caused by illegal coal pillar mining leading to goaf water connection. With the increase of mining depth, many mining areas in Shandong province have begun to lower coal mining; coal floor confined aquifer water pressure is becoming bigger, serious threat group of coal mining safety. Part of the mines, such as Suncun coal mine and Liangzhuang coal mine, inrush areas have no obvious structures, showing floor threat of confined water is more concealed and more dangerous. Therefore, the goaf water and Ordovician water are the major source of coal mine water-disaster in Shandong province.

2.4Water-disasters occur with close links to the geological conditions and climate

In the plain area, with undeveloped karst, crack, the mine is mainly affected by the Quaternary loose bed water. In mountainous and hilly terrain, coal seam outcrop exposed big, rich groundwater resources, receptive to recharge, threatened by confined water surface and Ordovician water more seriously .In the top group of coal mining, coal mine water-disasters are given priority to the roof and floor conglomerate, sandstone water. In the low group of coal mining, the mine is mainly influence by Xu limestone and Ordovician water.

The rainy season of Shandong province is mainly in July and August, during this period, the mine accidents are significantly more. For example, in July and August, 2008, different degree of water inrush accident happened in Tianranjiao mine and Jingting mine of Zaozhuang coal, Wanglou mine of Linyi coal. Surface water can not only directly crush into the underground; also it can offer the groundwater recharge, becoming the indirect water source of mine flood.

3 The main existing problems

The primary problems of flooding injury prevention and cure in coal mine of Shandong province:

1）Hydrogeology information is not clear. Comprehensive analysis of hydrogeology is lacking in some mines, such as empty water surveys around gob areas are not timely and accurate; a few mines lack of geological exploration work seriously, leading to incomplete geological data and unclear hydrological conditions, such as Wanglou Coal Mine and Juncheng Coal Mine's lake district and deep coal seam have few drillings and not enough hydrological and geological information, which make it difficult for water prevention and control.

2) Some old mines(such as Zibo, Zaozhuang, Xinwen, etc.) still exist having not enough hydrogeology information due to a long mining history, leading to lots of ancient empty and old kiln, and are subject to threats of flood season precipitation, surface water, especially Mining area of Taozhuang; Local provincial coal mines are distributed in marginal outcrop or abandoned mines re-mining's residual coal nearly, mining relationship is complex between mines with more rainfall of recent years, the rise of ground water level, head water pressure's increase, old empty water growth, having larger threat to safety production of coal mines.

3) Large trough coal and shallow coal seam are facing exhaustion of part of mining area, gradually coming into the exploitation of the next group mine. The high confined water's threat of floor is serious and water inrush risk is increasing, both of which increase the difficulty of water disasters prevention.

4) The mines of Jining mining area mostly distribute along rive and lake, especially mining area affected by mining is increasing gradually per year in recent years, such as working faces near rive levee and lake levee grows, leading to hard flood control. Although individual mines have taken some measures for rive channels, flood discharge, water pits, subsidence area, ground cracks, ancient kilns, etc. but governance is not complete,

existing a phenomenon of having hidden threats and governing every year.

5) Part of old mines in order to reduce displacement; the mining area has been blocked. This action leads to high lift water problem, posing a threat to production area.

6) Attention to water prevention and control is not enough. A few coal enterprises have insufficient understandings of water disaster control, evading hidden perils during the damage analysis and describing dangerous circumstances roughly and simply, and lack of specific targeted treatment and prevention measures. Flood prevention work mechanism is weakened in some mines, including unclear responsibility, inadequate mechanism, less professionals, wakening management work, even having no hydrological professionals in several mines

4 Prevention and control methods of water-disaster in Shandong province

The following measures are given for the basic characteristic and main existing questions about Shandong province mine water disasters.

4.1Finding out mine hydrogeology situation

Mine or mine area hydrogeology situation was found out by combining mine geophysical prospecting, drilling, geochemical and some advanced applicable technology. Collect and survey periodically this mine and neighboring mine abandoned old kiln situation, quickly and accurately compile the “mine comprehensive hydrogeology situation” and some basic drawing and information in order to realize mine water disasters potential threat situation and come up with relative measures which could prevent in advance and handle water disasters could improve mine waterproof ability. When drilling in the mine, explore and drain water must be in accordance with the principle of digging after exploring, and meanwhile make sure draining water effect. Jining city insists to take ascertain mine hydrogeology type as important point whose mines have all finished hydrogeology type division in order to do enough waterproof work.

4.2 Using new technology and theory study mine water inrush mechanism

Water disasters mechanism and theory study are developed. Physics simulation and numerical simulation are attached importance strengthened, and come up with new realization and understanding. It brings much convenient to waterproof work by utilizing computer information to create waterproof synthesis information base and diagnose system such as region and Shandong province networking which could reach

contacting information and data sharing. Feikuang group, high college and science and technology enterprise cooperate to carry out mine water inrush mechanism study Ordovician hydrogeology expedition and treatment technology study, and search new coal mining method so that keep mine safe.

4.3 Establish and complete the waterproof system

In order to make mine water disasters prevention work develop successfully, we should establish and complete mine water prevent responsibility system, precise division, close cooperation and order work. All kinds of enterprises should strengthen contact with geography measure, weather, waterproof and some sections, and establish to prevent water disasters, predict handling mechanism and sharing mechanism. When somewhere of mine appear to dangerous situation, it must inform quickly circumjacent all mines. When relative people receive dangerous reports or possible disasters, it firstly disposes them before reporting. Yankuang group explore actively to establish long and effective mechanism waterproof safety administration and strengthen waterproof technology administration which realize mine area waterproof safety production for 13 years.

4.4 Increase funding

In order to improve mine emergence prevent drainage ability and make mine develop safely, continually and stately, we must increase prevent govern water equipment funding, improve mine emergence prevent drainage ability and corollary equipment which could meet the need of production, and meanwhile mend drainage equipment regularly and arrange emergence drainage water material and equipment. In addition, we should strengthen manage funding, for example Xinkuang group spent 120,906,200 Yuan managing Caiwen river area first and second project which remove mine surface water disaster danger.

4.5 Improve safety train

Mine water disaster accidents depend on human error largely. Water inrush accidents could be reduced by adopting a serious of measures, despite of complex mine condition. Zikuang mine group invite “mine waterproof rule” main drafter to explain, train and combine fact work to revise “waterproof work detailed rules” in order to avoid water disaster accidents.

5. Conclusions

The geological condition of Shandong province is very complicated; coal mines often face various water-disasters when mining. Mine

water-disaster management has been the safety production problems which must be solved; it needs to check out the hydro geological conditions and summarizing the characteristics of water disasters. Finally, targeted prevention method could be presented. When preventing water disasters, it also need to comply with relative rules and combine mine fact situation to adopt positive measures in order to reduce water disaster accidents to minimum margin.

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