Ordovician Limestone Water Control in North China Coalfield

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ABSTRACT

Coal mining in north China has been threatened with ordovician limestone karst water.Ordovician limestone has plentiful karst water and complicated hydrogeology conditions. We have studied for extracting coal seam under such conditions, and have accumlated a wealth of experience.

This article discribes how to control karst water for coal mining in diferent cases.

DETAILED INSTRUCTION

Permo–carboniferous coalfield in north China is a main coal base in China. It has rich reserves with various coal ranks and distributes in a wide range of area, including Shanxi,Hebei,Shandong,Henan,Jiangsu,Anhui and Shaanxi provinces, north to Dabie mountain (in Qinling range),south to Yinshan mountain, east to Helan mountain and west to Tanlu fault.

Coal production in north China coalfield is severely threatened with mine water from 1000m–thick ordovician limestone underlying the coal series. Water inrushing and submerging mine often occured in mines. For example, there were 1600 water inrushing and 222 submerging mine accidents during the thirty years from 1956 to 1985. Especially about 22 submerging accidents occured from 1984 to 1985, which caused economic losses about 70 million Yuan(R.M.B.). Fan Gezhuang coal mine,Kailuan Coal Mine Bureau,met a big water inrushing with yield of 2053 m^3/ min on mining face 21712.It is a unprecedented event during the mining history.After many years' researching and testing,a lot of experience and obvious effects in control of mine water are obtained.According to the different hydrogeological characters,the control methods are discribed as follows:

1. Where coal strata between mining coal seam and ordovician limestone have several thin limestone layers which have been related with ordovician limestone caused by faults,the

groundwater supply of thin limestone should be cut from ordovician aquifer and groundwater pressure dropped down by dewatering underground in the thin limestone.

For example, Jiao zuo coalfield is one of the coalfields threatened with great amount of water.There are 11 coal mines which have to pump 400~ 500 m^3 / min water (455 m^3 / min in average),the electricity expense for draingjng water is 22.7 million Yuan per year,Jiu Lishan mine has to pay 11.67 Yuan for pumping water for one ton coal.It is evident that water is severely influencing coal production in this bureau.According to the statistic data,we know that it is the thin limestone (L_8) which is supply resource of coal mine water inrushing,and L_8 accepts water supply from ordovician limestone and surface alluvium.In order to clarify the location where L_8 accepts water supply,many synthetic explorations were used near the area of hiding outcrops of L_8, such as electric method,drilling,hydrochemical tracing,electromagnetic wave perspective in bores,temperature measure inside bores,water table fluctuations measure,etc.It had been verified that only 1.5~2.2 km outcrops of L_8 can obtain water supply from alluvium eventhough the hiding outcrops of L_8 is about 5.5 km long.So we can limit our grouting to a small area.

After explorations we grouted on the ground to cut water supply of $L_8$from alluvium.Considering the water flow velocity is very high (about 533 m / min),we filled the passageway with bone materials (such as sand).After having been pouring sand (about 800 m^3) for about four months,we reduced mine water yield from 90.2 m^3 / min to 80.2 m^3 / min.

Based on above, we took several kinds of controlably dewatering from thin limestone according to the saturated differences of the limestone,in order to depress the hydraulic pressure in the thin limestone.There are three types of dewatering methods:with tunnel,from underground drill and from water inrush places.They are respectively suit for such cases as water yield is large,water yield is small or the aquifer has not plenty of water (in which cases the dewatering drill hole should properly disperse to extend the range of depressing pressure and to avoid interfering among the bores),and the aquifer has plenty of water.

2. Where the impervious layer between coal seam and upper surface of ordovician strata is very thin (about 15~20m),and also ordovician aquifer directly supplies mine water.

The yield,supply resources and passageway of plentiful aquifer should be first investigated by means of synthetic methods(such as geophysic,geochemical and drilling explorations,and also pumping and dewatering tests),and then the capacity of anti–water increased in a planned way. In the meantime,coal could be mined in different areas under different groundwater pressure by completely using valid impervious layer.In order to solve the problem of how to completely use valid impervious layer, the following should be done:

a) Mining pressure's damaging deepth and strength to the impervious layer.

b) Pouring water into the impervious layer with constant water pressure after three months when strata become steady.

c) High water pressure pouring test in the valid impervious layer where has not been influenced by mining pressure.

d) Observing the height of groundwater rising from ordovician strata into the lower impervious layer.

Detecting and forecasting of water inrush warning signs.

Based on statistic data,more than 80 percent water inrush accidents occured on mining face,and most of which caused by structures.In recent years,we forecasted water inrush as the following steps:

First,draw up a three–dimensional structure figure for impervious rock pillar (from surface of ordovician layer to bottom of coal seam),on which the spatial variation were shown,and the possible water rising locations could be analysed .

Second, verify the locations by means of digital electronic instrument and radio–activity measurement.

Third,determine the locations and water rising height by means of dilling.If mining face is located above the heavy passageway of groundwater,water pressure and water yield within impervious limestone should be explored by drilling along the lower and upper tunnels beside mining face.If water pressure exceeds the pressure which impervious layer can bear,water pressure must be reduced by dewatering(especially in faults zones),and then the broken zones or karst caves and fractures within thin limestone will be sealed by grouting,in the meantime,stoping face should pass quickly in order to reduce leading support pressure's damaging to the impervious layer.

Fourth,at the possible water inrushing places, water inrush forwarning detector is used.This detector has stress,strain,temperature and moisture probers,which are buried in the impervious layer.

Based on the prospective data for the first time,stress,strain and temperature in impervious layer had evidently variations about ten days before water inrushed.The variation regulars are that rock stress reduced and strain increased obviously,and also temperature tended to be up and down.We conclude that this method will be helpful to forecast water inrush and has a likly developing prospects eventhough there are many problems.We will make deeply research in practice in order to serve validly for coal mining in our country.

3. Where the passageway of mine water inrush is subsiding pillar. Water control should be taken as main step.

Subsiding pillar is formed by continuously collapsing from over strata into the karst caves.It mainly distributes in Fengfeng,Jinjing,Yangquan and Huoxian coal fields.There are a few subsiding pillars exist in Fan Gezhuang,Kailuan coal field,Yeyi,Anyang coal field,and Qing Shanquan,Xuzhou coal field.They look like ellipe on plane,and triangle on section.They vary in size,the largest one is 580m,and the smaller is several meters in diameter.

There are two types of subsiding pillars,one is ancient–forming and the other is current–forming.The former is vertical to strata run and mostly can not be full with or transmit water flow,the latter is vertical to ground plane and mostly are full with or transmit water flow.

It should be pointed out that both types always locate above the heavy passageway zones of groundwater flow. So,if we know where is the subsiding pillars,the passageway zone of ground–water flow can be supposed,it is the same the other way round.

Based on the general tests above and analysis, the dangerous places and safe water pressure can be known, and water inrush forwarning detector (developed by ourselves) should be used to forecast the possibility moment of water inrush in the prospective field.

Detailed Instructions for Some Tests

Mining pressure's damaging deepth and strength to the upper impervious layer.

In China, about five times of such test had been taken in several different kinds of coal field,each time some new methods were increased. The observing content included stress distribution within the impervious layer, rock displacement in drill and tunnel displacement,mining pressure,supersonic wave's velocity transmitting within impervious layer, pouring water through drill holes (in order to observe difference of water disperging in holes before and after mining),temperature and rock sound. Some conclusions were obtained as follow:

1) Mining pressure's damaging deepth to normal impervious layer is about 10m,but twice as much to broken layer.

2) Layers damaged by mining pressure can bear certain water pressure only when mining pressure disapears (about 60m away from mining face).Normal layer can resist against water pressure 0.4～0.6 Mpa,however innormal layer can only resist against 0.15～0.25 Mpa.

3) The main damaged zones are 5～6m away from the upper and lower tunnels beside mining face,and the damaging deepth and strength near the lower tunnel is much bigger than it near the upper tunnel.

4) Stress in impervious layer is 10 times as much as mining pressure.So leading support pressure is thought to be the main force resource which causes rock layer damage and deform,and this shows that the roof pressure's damaging to coal seam's bottom is much less than leading support pressure's.

5) Mining pressure's damaging deepth and strength to the impervious layer can be reduced if mining quickly or room–and–pillar mining method is used when stoping face passes through broken zones.

6) Influenced by mining pressure, faults may be activated,that is to say,unconductive fault may become conductive fault.

Exploration for ordovician limestone water's rising height.

Influenced by structure stress,there are many faults and fractures exist in impervious layer.If these faults and fractures intersect each other,and when impervious layer supports water pressure from underlying aquifer,the water may rise at certain height into impervious layer along faults and fractures.This height (from the top of rising water to surface of ordovician aquifer) is called ″water rising height″.

After explorations and underground tests,we know that the distribution of water rising height has the characters of unhomogeneity and uncontinuity,in section water head looks like sawteeth.

Because water rising height has these characters,the thickness of valid impervious layer must be with exception of water rising height.

Because there is close relationship between subsiding pillar and heavy passgeway zone of groundwater,we must analyse where is the passageway by means of hydrogeolgical methods,and then determine the exact locations of subsiding pillars by means of geophysical and drilling explorations,at last grout to seal subsiding pillars.

Grouting from surface of the earth is often adopted because it can give good effect,but if it is too expensive,preserving anti–water coal pillar method should be used to avoid subsiding pillar.