Evaluation of Safe Mining on Confined Water of No. I1 Coal in Micun Coal Mine

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Abstract

Geological hydrology condition, structural environment, aquifuge thickness, and coal bed thickness of No. I1 coal in Micun coal mine of Zhengzhou Coal Industry (Group) Co., Ltd., were analyzed. Possibility of water inrush from motherboard of No. I1 coal was appraised. Major factors of induce water inrush were analyzed. Furthermore, danger area of water inrush was divided. It was indicated that safe mining on confined water at thin coal bed can be carried on, after corresponding water prevent layout.

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1. Introduction

Water inrush from motherboard of coal mine refers to the disaster phenomenon that groundwater of confined aquifer under coal bed rushes into mining surface suddenly, and enhances water inflow or floods mine. It is major determining factor of safety mining. Due to decreasing of recoverable reserves of main mining No. II1 coal, Micun coal mine of Zhengzhou mine zone was judged of light crisis mine. In order to solve existence and development problems of mine, No. I1 coal was planned to mine. Thickness of No. I1 coal is only 1.04 m, it belongs to typical thin coal seam. Indirect motherboard is a thick seam of Ordovician limestone, which is generally considered as a water rich aquifer. Direct motherboard of Benxi group bauxitic mudstone in this area has an average thickness of 8.14 m, and decreases even disappear somewhere. Ability of water-resisting is limited. The hydraulic head elevation of the Ordovician limestone aquifer is 140 m. Mining of No. I1 coal is a typical mining under pressure. Mining under so high water pressure, may cause high fatalness of water inrush. After analyzing geological factors of causing water inrush one by one, water inrush disaster feasibility of mining under pressure of thin coal seam in Micun coal mine was assessed, in order to make proper water prevention measure.
2. Analysis of water inrush in study area: factors of water inrush from motherboard mainly include water rich instance, thickness of aquifuge, fault structure, and thickness of coal seam

2.1. Analysis of water rich instance of aquifer

Water rich instance of aquifer is the basic condition that deciding the quantity of water inrush from motherboard and whether water rush from rush point permanently.

Confined aquifer of Ordovician limestone karst cracks is the main aquifer, it only has an average thickness of 8.14 m to upper No. I1 coal. It is a confined aquifer which threatens to mining of No. I1 coal. Unit water inflow is 2.021~2.468 L/s·m, the coefficient of permeability is 3.670~9.670 m/d. It has rich water. But a mass of drilling holes data indicates that development of Ordovician limestone karst cracks and water rich instance are uneven. In vertical direction: drilling holes explore that Ordovician limestone has a mass of inflow water or leakage in some parts, for example No. 4-03 drilling hole; for the upper of Ordovician limestone in the range of 12 m, it is filled by bauxitic clay, and almost has no water in some parts, for example No. 6-02 drilling hole; drilling holes reach water rich parts after drill into more than 50 m of Ordovician limestone in some parts, for example No. 8-01 drilling hole, it reaches water rich parts after drills into 73 m to upper of Ordovician limestone. Extend down to Cambrian limestone, karst cracks develop badly, water rich decreases obviously. Karst cracks development elevation in Micun coal mine is mainly in range of 0~100 m. For the difference of landform, physiognomy, and buried depth of dissolubility limestone, karst development depth deepens from west to east step by step. Furthermore, since stream concentrates and increases to east step by step, karst effect increases accordingly. Moreover, erosion effect and corrosion effect of groundwater increase to shallow parts step by step. In horizontal direction: drilling holes data indicates that visibility factor of karst is 23 %, only 0.10~0.60 m karst holes and karst caves are observed in drilling core. Common development of Karst cracks and small karst holes shows the characteristic of limestone karst development. According to the mass drilling holes data, hydrogeological data, well logging data, and electrical prospecting data in Micun Coal mine, Ordovician limestone aquifer water rich bond was divided in Micun coal mine.

2.2. Analysis of water-resisting ability of aquifuge

Aquifuge thickness, intensity, integrality, and lithology are main factors to restrain water inrush of well [1]. In the common water pressure condition, more thickness of aquifuge, more intensity, and more integrality will get more safety in mining. Benxi group bauxitic mudstone aquifuge is lie upon the confined aquifer of Ordovician limestone karst cracks, is direct motherboard of No. I1 coal. According to drilling data, thickness of this seam is 0.5~17.31 m, average thickness is 8.14 m. The structure of this seam is density, smooth feeling, karst cracks do not develop. Aquifuge thickness of No. I1 coal in Micun coal mine is very thin, and bauxitic mudstone belongs to soft terrane, these reduce the unitary ability of resistance water pressure of aquifuge. Furthermore, aquifuge is cut down by small faults, integrality of terrane is broken, which reduce consumedly the ability of resistance water pressure of aquifuge. Therefore, the ability of resistance water pressure of aquifuge of bauxitic mudstone is limited generally. On the other hand, karst of top part Ordovician limestone which is under part of bauxitic mudstone, does not develop, terrane is density, intensity is great, has not water, these can be regarded as a part of aquifuge. These increase thickness of aquifuge, help to resist water pressure of under part rich water area, decrease the fatalness of water inrush from motherboard in general.

2.3. Fault structure

2.3.1. Analysis of large and medium-size fault water-transmissible

According to statistical data, 80% water inrush accident is caused by water inrush channels communicated with aquifer in large and medium-size fault, result in working surface water inrush sequentially. Therefore, it is necessary to analyze detailed water-transmissible capability and whether forming water inrush channels. According to the prospecting data, there are four prospected large and medium-size faults in Micun coal mine.

2.3.1.1. Qiangaocun fault

It is normal fault of large angle tenso-shear in south of well boundary. Fault increases in south, decreases in north, goes near to EW, leans to N, obliquity is 60 degree, fall is 70~250 m, extending length of this area is 15 km, extending length inside the area is 6.75 km. Near No. 3 prospecting line, fall of fault is big. No. II, coal seam connects with Cambrian limestone directly. In theory, limestone karst water of this part will supply to sandstone aquifer of roof of coal seam. It will
induce accretion trend of roof shower water while working surface goes near to cracks in mining area. But in practice mining, accretion trend of roof shower water does not show while working surface goes near to cracks, while increase with accretion of mining area, and drainage of roof decreases on the contrary. These may relate to underdevelopment of karst cracks in this part. Therefore, it is deduced that this fault near No. 3 prospecting line is not water-transmissible. Near the 3B prospecting line, fall of fault is small of 75 m. No. II1 coal seam joints with limestone part of Taiyuan group bottom. Since the coating effect of middle sility mudstone part, this fault is judged as no water-transmissible. Near No. 6 prospecting line, channel of small coal mine in Wangzhuang well passed Qiangaocun fault going along Huanglongquan fault two sides, and entered Micun well, destroyed 26021 and 26011 working face. At that time, water pass through faults was small. But now, water inflow shows increasing trend. It indicates that filled mudstone and Sility mudstone in these faults have ability of water-resisting. On the other hand, as the recovery areas increase, destroy intensity of mining activity also increase, they destroyed filled materials in fault band, and conducted fault water-transmissible. It can be explained that faults are not water-transmissible in No. II, coal seam near No. 6 prospecting line, under part may be water-transmissible. According to the faults transient electromagnetic exploration repart of Micun coal mine boundary, there is a strong water rich area between No. 6A and No. 6A1 prospecting lines, and shows accretion trend of roof shower water in No. 26 mining area, it indicates there is water-transmissible in this location. On the other hand, confined water elevation of Micun well is about +140 m, confined water elevation of Wangzhuang well is also about +140 m. Two wells have relationship of water. These indicate that there are water-transmissible parts in Qiangaocun fault, and there are no water-transmissible parts in upper No. II, coal seam joining parts, there are good water-transmissible capability in under parts.

2.3.1.2. Yanjiamen fault

It is large angle tension positive fault in western well, western part of fault increases, eastern part decreases, goes towards to NE, leans to SE, obliquity is 63 degree, and fall is 58 m, well boundary extends 1.25 km, disappears to southwest of 500 m to Qiangaocun fault. No. 3-01 drill explored this fault. Limestone of No. 7 and No. 8 layers disappears in Taiyuan group under No. II, coal seam, and fault breccia is found, fault gist is sufficient. According to manufacture exploitation, at the disappear part of fault extending to southwest, motherboard of coal forms drape, and coal seam continues. For No. II, coal seam, it joints with sility mudstone parts of middle Taiyuan group directly. According to the paste action, it can be deduced that this part is not water-transmissible mining in No. II, coal seam. But, owing to part of L6 limestone does not transform to sility mudstone, it may cause water-transmissible if it joints with No. II, coal seam directly. For No. I, coal seam, it joints with Ordovician Majiaogou group limestone directly, possibility of water-transmissible is great. Therefore, it is believed that upper part of Yanjiamen fault is partial water-transmissible, most of under parts are water-transmissible.

2.3.1.3. Zhangwan fault

It is large angle tension positive fault in eastern well, eastern part of fault increases, western part decreases, goes towards to NE, leans to SW, obliquity is 60 degree. According to location drills and water exploration of Zhangwan fault in Micun coal mine, fall of Zhangwan fault is far smaller than original estimation fall. It is deduced that fall of Zhangwan fault is 20~40 m now, and fault location moves to southeast 120 m, it is fault group with a small fall. Southwest well boundary extends 2.30 km, southwest well boundary is block off by Qiangaocun fault. In all well, No. 8 and No. 10A prospecting lines go through Zhangwan fault in deep part of well. Two prospecting lines joint with Ordovician limestone directly. Rock jointing with upper and under faults is predominantly brittleness rock. Namely, upper and under faults joint with brittleness rock. Therefore, fault is water-transmissible in this part. According to geophysical prospecting report, there is a strong water rich area within 60 m in No. 8 prospecting lines and the part that go down along Zhangwan fault jointing with Qiangaocun fault. Moreover, during practical mining, a water inrush point was found in No. 28071 working face near by Zhangwan fault, and water inflow of this working face is relatively great than the other. Therefore, it is deduced that fault is water-transmissible in these parts. Furthermore, according to location drills and water exploration of mining in Zhangwan fault in Micun coal mine, it is known that location of Zhangwan fault moves to southeast 120 m, and fall of fault is also far smaller than original estimation fall. Fault is a fault group, and rock is smash relatively. Owing to no water is found in two drills, it is deduced that it is not water-transmissible in these part of Zhangwan fault. Therefore, Zhangwan fault is also partial water-transmissible.

2.3.1.4. Hougaocun fault

It is positive fault in southern well, southern part of fault increases, northern part decreases, goes towards to EW, eastern part is nearly parallel to Qiangaocun fault, this fault and Qiangaocun fault intersect, and lean to N, obliquity is 60 degree,
fall is 20–44 m. It increases gradually from east to west. According to practical mining, eastern part of this fault extends to the east and disappears near No. 7-8 drills of No. 26061 working face. It disappears near No. II orbit channel, and that part shows group distribution, there are 3 lines. Since the coating effect of middle silty mudstone part, this fault is judged as no water-transmissible. Owing to part of L6 limestone does not transform to silty mudstone, it may cause water-transmissible if it joints with No. IIi coal seam directly. For No. Ii coal seam, it joints with Ordovician Majiagou group limestone directly, possibility of water-transmissible is great. Therefore, it is believed that upper part of Yanjiamen fault is partial water-transmissible, most of under parts are water-transmissible.

Above mentioned four faults are all partial water-transmissible faults, and some faults induce that No. Ii coal seam joints with Ordovician Majiagou group limestone aquifer, increases water inrush fatalness in mining No. Ii coal seam.

On the other hand, there are four blind faults were explored practically with fall of 10 m<D<20 m during the process of laneway drilling and working face recovery when No. IIi coal seam was exploited, and fault zone mostly is filled by fault mud. Thereinto two faults forming on No. 18 bord-up are near to Yanjiamen fault, they form a horst structure, and distribute in the shallower part in well. Fault formed at No. 21 channel, and No. 26 coal drop, lies at disappear location of Hougaocon fault. Fault formed at No. 15 mining area, is near to Zhangwan fault, and distributes in the shallower part in well. It can be seen from the four faults that form of these faults has consanguineous relationship with large and middle-size faults. They are all due to partial stress concentration built in diastrophism and draught action of upper and under parts of fault in formation process of large and middle-size faults, and stress is beyond the bending strain limits of terrane, terrane releases stress in form of fracture diastrophism. Finally, middle and small-size faults with relatively large fall are formed. According to similitude law, it is very possible to meet similar faults in mining process of No. Ii coal seam. Water inrush fatalness is great, because location and properties of faults are not clear before mining.

2.3.2. Effect analysis of small faults on water inrush from motherboard

Beside boundary fault in Micun well, there are great deal of small faults. Since setting of barrier pillar in known large and middle-size faults, common water inrush fatalness is not great if it is clear of properties of fault and setting of barrier pillar before mining. But, small faults with fall of less than 10 m developed in well. It shows mostly stretching relaxed state at faults connecting, disappearing, swerving, and complex parts. Physical properties of terrane is bad. Deformation and instability are easily occurred. It forms strong leakage channel after confide water enters. Small faults are more serried, water rich and water-transmissible are better, and water inrush is easier occurred. Times water inrush from motherboard was occurred in mining upper No. IIi coal seam of Micun coal mine and No. Ii coal seam of border upon Wangzhuang coal mine all previous, they are all due to exploring of small faults [2]. Therefore, as a very important factor, serried small faults band hold the very large proportion in prediction of water inrush in mining No. Ii coal seam of Micun coal mine.

2.4. Relationship analysis between thickness of coal seam and water inrush

As mining thickness increase, gob area increase, and well pressure of motherboard also increases. Water inrush is easier in first pressure of location especially [3]. Average thickness of No. Ii coal is only 1.04 m, it belongs to typical thin coal seam. Well pressure is small, relative to mining under pressure in thick coal seam. It benefits to motherboard counteracting to confide water in mining.

3. Division of water inrush fatalness

According to above mentioned analysis of water rich of aquifer, fault water-transmissible, distributing of aquifuge thickness, we decide distributing of water rich area of aquifer, water-transmissible fault, and thin aquifuge in Micun coal mine, and divide danger area, threaten area, and safe area of mining in No. Ii coal thin coal seam motherboard water inrush in Micun coal mine aftertime (as shown in figure 1). General water inrush fatalness division results are:

![Fig. 1. Prediction evaluation of water inrush from motherboard of No. Ii coal in Micun coal mine](image-url)
(1) The safe area is basically above +100 m, in the central mine. Owing to the small structure is not developed, water rich is weak, safe area is extending to the deep extension. But there are the intensive minor faults and close to mine boundary these area, are threatened areas.

(2) The threaten area is basically between +100 to +50 m. In the central mine, the minor structure does not develop, water rich weakly, the threaten area is extending to the deep extension.

(3) The danger area is basically below +50 m.

4. Conclusion and advice

Micun well is a close-half close hydrogeological unit, aquifer reserves of indirect motherboard of Ordovician limestone are abundance, but uneven. Only parts of them are water rich area. It decreases water inrush fatalness greatly.

Owing to the thickness of Benxi group bauxitic mudstone aquifuge is very thin, ability of water-resisting is limited. Closing to Ordovician limestone confined aquifer more, water inrush fatalness increases greatly. On the other hand, karst in upper part of Ordovician limestone is not developed, almost has no water, upper part can be used as aquifuge to resist water inrush. Therefore, water inrush fatalness decreases.

Middle and small-size faults structure are development in well, and break the integrality of Benxi group bauxitic mudstone aquifuge. There are plenty of confined water near small fault structure, it increases water inrush ratio. Large and middle-size faults are partial water-transmissible faults, form directly jointing of No. I1 coal and aquifer, it increases motherboard water inrush fatalness near faults.

Owing to mining of thin coal beam, mining-induced is small, it decreases motherboard water inrush fatalness.

Keystone of water prevent layout of Micun coal mine should be to find out accurately water rich area distributing of under part of Ordovician limestone, water inrush prevention of faults and working face under +50 m. mining on confined water at thin coal bed can be carried on, after make corresponding water prevent layout.

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