Application of “Trifigure-double Prediction Methods” in Water Disaster Prevention and Treatment Evaluation of Pingshuo NO.3 Mine Shaft Top Roof

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Abstract

Pingshuo NO.3 mine lies in rising end of Ningwu anticline. With the special tectonic site and landform condition, roof water of coal seam and subsurface water communicates, making top roof water disaster of mine very serious, and water disaster times and water surging amount is rarely seen in China. With advanced “tri figure-double prediction methods”, we evaluate the dangers of top roof water surging, and take consequent measures to treat water, obtaining fruitful achievement.

Keywords: Tri figure-double prediction methods; water guiding fracture zones; water surging quantity of mine; surface dredge.

Foreword

Pingshuo NO.3 mine belongs to China Coal Energy Company Ltd. Its mining method is inclined shaft-underground mining, producing 10 million t/a. In the process of shaft building, water inrush occurred many times in the shaft with water bursting quantities of 4000~6000 m³/d, and the largest quantities reaches 26400 m³/d, which is rarely seen in China. This article analyzed the danger of water inrush in well field top...
roof, applying advanced “tri figure-double prediction methods”, in order to make a basis for treatment of water disaster in well shaft.

Water inrush in coal seam roof is a direct water disaster in coal field. If aquifer water-richness in roof is strong enough, the water inrush will worsen working conditions. It is a difficult subject in coal deposit hydrogeology how to make a quantitative evaluation in water inrush danger of coal seam roof in order to carry out scientific water treatment measures. The traditional method just researches its affecting factors in a qualitative manner, not in a quantitative manner. Professor Wu Qiang, Chinese University of Mining and Technology, put forward a “Tri Diagram-Double Prediction Method” in a quantitative manner, resolving the problem of water rush in coal top seam. Now we make a simple introduction of application of “Tri Diagram-Double Prediction Method” in water disaster treatment evaluation in Pingshuo NO.3 mine.

1. Brief Introduction

The minable coal seam of mine shaft is Carboniferous Taiyuan Formation No.4, No.9, No.11 coal seams. The main full water aquifers closely related to mine shaft are four layers rock sand K4, K3, T4, T3 in coal seam roof.

The rock is mainly characterized by coarse grain sand rock and medium-sized sand rock. No 3 mineshaft lies in the rising end of north Ningwu syncline, whose coal seam and roof sand rock buried shallow and weathering a lot. Ground water is the main water supply source of mine shaft, and weathering fissure in aquifer develops a lot, which is the main cause of water disaster of mineshaft.

2. Study on water richness in No 9 coal roof full water aquifer

Through comprehensive research of geological information on rock property change, structure field, hydro chemical field, geophysical field, water pumping test field, there is 9 coal roof aquifer water richness zone.

2.1 Lithology and rock property change characteristics

The ratio between sand rock aquifer thickness, brittle rock (mainly coarse grained rock) and plastic rock (mainly siltstone and mudstone). The thicker the aquifer was, the larger the ratio of brittle rock and the larger the water richness was.

The total thickness of coarse-grained aquifer in mineshaft is 13.68～55.95m, 34.34m in average. In the southwest part of mineshaft and axis part of syncline, thickness is 40～50m, the other part is 20～30m in average (Fig. 1).

In the vast sections of mineshaft brittle rock thickness is larger than plastic rock, and the ratio lies between 0.20～2.30. in the southwest part of mineshaft, the ratio is between 1.50～2.30. In the east part, the ratio is nearly 1.0 (Figure 2).

The above-mentioned characteristics decide that No.3 mineshaft develops along coal roof aquifer fissure in the neighborhood of Dashagou. With a lot of aqueous capability, it provides basis for water richness in aquifer.

2.2 Tectonic characteristics

NO 3 minefield lies in northwest part of Ningwu coal field, rising end of Ningwu syncline. Because of tectonic stress in this section, tectonic fissure and weathering fissure in coal seam outcrop in west
minefield develop a lot.

2.2.1 *F₁* fault
The fault throw is larger than 5M, at the depth of 120m. Apparent resistivity: 23Ωm and distributes contently and relatively water rich (Fig. 3).

2.2.2 *F₂* fault
The fault throw is larger than 5M, and the apparent resistivity is relatively low. At the lower end of fault exists low resistivity zone (21Ωm). It is conductive fault with local water richness. (Fig. 4)

2.2.3 *F₂₄* fault
The fault throw is 2.3m. According to the information, it is conductive fault with water richness. Analysis of tectonic field characteristics show that, because of concentrated stress, a lot of faults exist, developing more tectonic fissure in aquifer. The atmosphere precipitation water, surface water and
quaternary system pore water can surge into mineshaft along sandstone sub outcrop. Therefore, aquifer in tectonic part is water richer.

3. Geophysical characteristics (instantaneous electromagnetic detection)

According to the outcome of instantaneous electromagnetic detection, the electric resistivity less than 18\,\Omega\,m is deemed as strong water rich zone, 18 \sim 22\,\Omega\,m as medium water rich zone, 22 \sim 24\,\Omega\,m as poorly water rich zone.

4. Water pumping test

Water is very rich in the southwest area of sub outcrop. According to water pumping test the unit water yield quantity of borehole is 5.2173\,l/s\cdot m.

5. Hydro chemical characteristics

Water quality analysis shows that sand stone weathering fissure, tectonic fissure develop a lot; water supply is strong in sub outcrop. Water runs off well, water is active in exchange, and ion content in water is relatively low. (Fig. 5). Far away from sub outcrop, weathering fissure is gradually weak, water runs worse, water is slow in exchange and ion content is relatively high in water. (Fig. 6)

6. Safety study on No.9 coal development top roof taking down.

6.1 Divisions principle

According to different aquifer location of conductive fissure zone, an analysis is to be conducted on top roof taking down.

Strongly dangerous area: coal mining conductive fissure zone develops up to surface, connecting sandstone aquifer, quaternary aquifer and ground water.

Medium dangerous area: conductive fissure zone develops up to top of basic rock into quaternary system
Poorly dangerous area: conductive fissure zone does not develops up to top of basic rock, connecting partly sandstone aquifer.

6.2 Height calculation of conductive fissure zone.

1. Empirical formula
The dipping angle of coal seam in minefield is $5^\circ \sim 10^\circ$, press resistivity of top roof rock is 20~40Mpa. Lithology of overlying rock is characterized by siltstone. Height calculation of conductive fissure zone is as follows:

$$H = \frac{100M}{3.3n + 3.8} + 5.1$$

Where,
- $H_t$ — height of conductive fissure zone (m);
- $M$ — thickness of coal seam (m);
- $N$ — layer number of coal seam.

2. Theoretical formula method:
The traditional empirical formula focus on sole factors, however, deformation of rock mass is related to the structure of overlying rock, rock mass mechanics strength, mining method and so on. Under the guidance of mining press control theory, Shandong University of Science and Technology put forward the following formula

$$h = \frac{1}{\eta} \left( 1 + C \frac{L}{\gamma H} - \frac{\tau}{\gamma H} \right)$$

Where,
- $h$ — development height of conductive fissure zone (m);
- $\eta$ — attenuation coefficient of top roof crest
- $C$ — transport coefficient of force between rock beam;
- $L$ — length of working section (m);
- $\tau$ — tensile strength;
- $H$ — mining height (m).

### Table 1 conductive fissure height calculation diagram

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<th>NO.</th>
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<th>No. of hole</th>
<th>conductive fissure height</th>
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</table>

6.3 Divisions of Results

According to two calculation methods, divisions of results are as Fig. 7.
7. Study on division of water burst condition in top roof of NO.9 Division results are as figure 8

Fig. 7. Coal roof taking down fissure zone safety division
Fig. 8. Evaluation map of top roof water surging dangers

8. Prediction of water burst in mineshaft

This article applies world-popular visual Modoflow ground water three dimensional numerical analogous software, predicting water burst in mineshaft. The calculation of hydrogeology can be briefed as: the west sandstone aquifer crop out, supplying atmosphere precipitation and ground water (Fig. 9). In total, the unit number is 72000, among which valid unit 43640, invalid unit 28360.(Fig. 10)

Fig. 9. Hydro-geological map
Fig. 10. calculation planar grid maps

9. How to treat water disaster in mineshaft

The direct source of this mineshaft water is sandstone fissure water in coal seam roof, and the ultimate source is seepage supply of ground water and atmosphere precipitation. Therefore, the most important measure to treat mineshaft water is to control seepage supply of ground water or precipitation. Through previous analysis of mineshaft water source, sub outcrop ground water seepage is the main supply source of sandstone fissure water near Dashagou. Therefore, flood dam must be built to outside sub outcrop, cutting off supply source.
10. Conclusions

(1) Applying “tri diagram-double prediction” principle, considering aquifer water richness and top roof taking down safety, etc, this article makes a semi quantitative evaluation on danger of water burst on top roof.

(2) No.3 mineshaft set underground drainage system according to three dimensional numerical prediction water burst in mineshaft, and makes great achievements in water treatment. Since such measurements have been taken, no water disasters occur in this mineshaft.

Reference
