

Research on Forecast Method of Multi-source Information of Water Disaster in Coal Mine

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Abstract Water bursting in coal beds is a serious problem that has existed in coal production. The forecast of possible water bursting area is an important subject to be solved urgently. Traditional prediction methods only consider single factor, so that the forecast accuracy is very low. In this paper, it is suggested that the information of structure, lithology and hydrogeology from coal-bearing strata in Geting Coal Mine is obtained from multiple geophysical data. Multiple factors about water bursting in the floor of coal beds are analyzed, and the prediction and evaluation model considering various factors is set up.

Keywords water disaster in coal mine, multi-source information, geophysics, forecast

Introduction

Water inrush in coal mine is a serious problem for long time in production. Inrush area forecasting is an important subject to be solved. Water inrush of coal seam is controlled by multiple factors of dynamic phenomena. Traditional research methods consider one point of view or single factor, so prediction accuracy is low.

Single factor prediction does not conform to the objective laws. It is more scientific and more accurate by using multi-factors comprehensive analysis. Zhang et al. (1994), Wu et al. (2000) researched water inrush prediction of coal seam and practiced by multi-factor. They have achieved good results.

Multi-source information prediction methods of water disaster in coal mine

Today, many geophysical methods have been widely used in coal mine ground hydrogeological investigation, and almost replaced traditional geological methods. In order to predict the mine water damage with multiple-sources information, the 3-D seismic (including conventional data volume and seismic attribute data volume), electromagnetic, structural geology and other multi-source information should be blended, unified, quantitative analyzed, then build a predictive and evaluation model to determine the hydrogeological anomalies.

The core problems of mine water inrush prediction and evaluation are follows.

- (1) Quantization of interpretation results (structural factors, lithology and hydrogeological factors).
- (2) A water inrush predictive and evaluation model should be built which conforms to hydrogeological characteristics in mining area. At the same time, the threshold values of factors will be determining.

Quantitative analysis of influence factor of water disaster in coal mine

The channels of mine water inrush include fissures, faults, collapse column and other structure, and faults impact greatly. 3D seismic data can identify the shape and structure of the coal seam, so it is necessary to quantify the results of the seismic structural interpretation.

Membership values of these three types are 1, 0.8 and 0.5. Membership value of normal area is 0. Finally, with seismotectonic interpretation results, we obtain the structural membership of water inrush.

Lithology factor includes lithology of coal-bearing strata, and Karst fractured zones in coal seam. Sum of weight is 1. With all seismic attributes normalization and unequal-weight superposition (fusion), seismic attributes water inrush membership will be obtained.

With electromagnetic exploration method, the values of apparent resistivity ascertain water-rich abnormal area in a horizon. It includes strong, middle and weak water-rich area. Membership of normal area is 0. Finally, we obtain the electrical (hydrogeology) water inrush membership by electromagnetic survey interpretation results.

Set up prediction and evaluation model of coal mine water inrush

There are two kinds of methods to empower values. One is mean-method. By this kind of method, weight of each factor is same. The other one is artificial assignment. It comprehensively analysis of various factors and specific conditions, then gives the weight of each factor. After the weight to determine the value of each factor, a model will be created to predict mine water damage.

Membership value of each factor should limit between [0,1]. This study use geophysical information, combine with structural geology and hydrogeology information, summarize factors of coal water inrush to following: affecting structure, lithology and hydrogeology.

(1) Use 3-D seismic interpretation results to obtain structural membership $A_1(x_1, x_2, \dots, x_n)$.

(2) Use 3-D seismic attribute volumes to obtain attribute membership $A_2(y_1, y_2, \dots, y_n)$.

(3) Use electromagnetic survey interpretation results to obtain electrical (hydrogeology) membership $A_3(z_1, z_2, \dots, z_n)$. Each of the factors contains many data.

The weight of each factor in water inrush is a_1 , a_2 and a_3 , membership of each point in the survey area is:

$$\begin{aligned} T_1 &= x_1 \times a_1 + y_1 \times a_2 + z_1 \times a_3 \\ T_2 &= x_2 \times a_1 + y_2 \times a_2 + z_2 \times a_3 \\ T_3 &= x_3 \times a_1 + y_3 \times a_2 + z_3 \times a_3 \\ T_n &= x_n \times a_1 + y_n \times a_2 + z_n \times a_3 \end{aligned} \quad (1)$$

With formula (1), we can acquire the membership $T(t_1, t_2, \dots, t_n)$ of water inrush in survey area. Acquire water inrush membership $T(t_1, t_2, \dots, t_n)$ of all points in the survey area, then divide water inrush danger zone by the membership value of each point $t_i (i=1, 2, \dots, n)$. Because the range of water inrush membership is 0-1, it can be set to 10 levels (incremental step is 0.1). Also, it can be set to 5 levels (incremental step is 0.2).

Essentially, coal mine water inrush evaluation is the result of considering three factors comprehensively. Evaluation of water inrush danger basic guidelines as following.

(1) It is defined as strong water inrush area when three kinds of factors in the area are abnormal. It has strong water-rich anomaly exceptional structure of coal-bearing strata. This area has the maximum probability of water inrush.

(2) It is defined as slightly strong water inrush area when two kinds of factors in the area are abnormal. It has strong water-rich anomaly and unusual structure, but crack is not. Either, it

has medium water-rich anomaly with exceptional structure and crack. This area has medium probability of water inrush.

(3) It is defined as weak water inrush area only when one factor in the area is abnormal. It has strong water-rich anomaly without unusual structure and crack, or structure and crack is abnormal, but water-rich is weak. This area has low probability of water inrush.

Application examples

Based on the 3-D seismic data and CSAMT data of 1160 mining area in GeTing coal mine, a plurality of Seismic attribute volumes have been extracted. Evaluating the water inrush danger quantitatively for 16# coal seam with structure information, attribute information and electrical information from 16# coal seam to Ordovician.

Figure 1 is 16# coal seam water inrush structural membership map. In this map, red is reliable fault (membership value is 1), blue is relatively reliable faults (membership value is 0.8), brown is reference fault (membership value is 0.5).

By analyzing and comparing, five kinds of seismic attributes have been selected to participate in 16# coal seam water inrush forecasting. They are peak amplitude, time domain average energy, low-band energy, dominant frequency and similarity coefficient. According to various seismic attributes for cracks and faults reflect the degree of sensitivity (contribution rate), definite each seismic weight as follows: peak amplitude 0.2, time domain average energy 0.3, low-band energy 0.08, dominant frequency 0.12, and similarity coefficient 0.3. Figure 2 is 16# coal roof and bottom water bursting seismic attribute membership map. In the map, the red and yellow areas correspond to abnormal areas. It is water-rich area. And the blue area has less water.

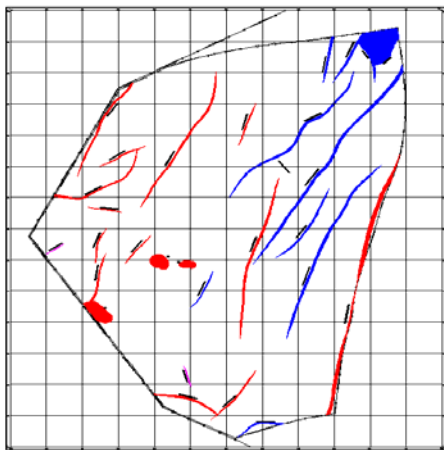


Fig. 1 Water inrush structural membership map of 16# coal in 1160 mining area

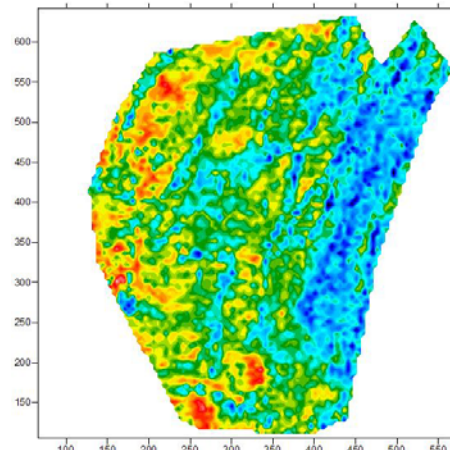


Fig. 2 Seismic attribute membership map of 16# coal in 1160 mining area

Electrical information of the research in this area uses CSAMT data. Figure 3 is 16# coal roof and bottom water bursting electrical membership map. In the map, deep blue is a strong water-rich area, water inrush membership is 1; cyan is medium water-rich area, water inrush membership is 0.8; yellow is weak water-rich areas, water inrush membership is 0.5.

According to variety of information, risk factors weight of water inrush will be determined, which structural membership value is 0.3, seismic attribute membership is 0.2, and electric membership value is 0.5.

Using equation (1) and single factor water inrush weight, a mathematical model could be built. In figure 4, the degree of risk is divided by water inrush membership. The blue represents strong water inrush area (membership > 0.8), the cyan represents slightly strong water inrush area (membership is from 0.5 to 0.8), the yellow represents weak water inrush (membership < 0.5).

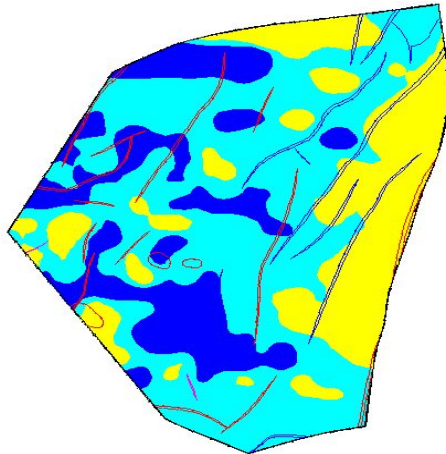


Fig. 3 Electrical membership map of 16# coal in 1160 mining area

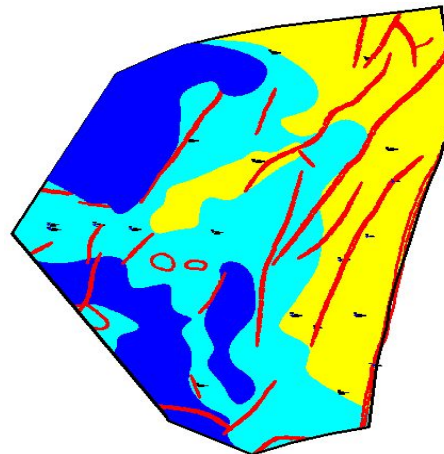


Fig. 4 Water inrush membership map of 16# coal in 1160 mining area

Conclusions

- (1) Using seismic attributes, structural and lithological interpretation is got.
- (2) Water inrush factors (structural factors, lithology and hydrogeological factors) interpretation results quantitative methods is proposed.
- (3) Using coal mine water disaster multi-source information prediction method, comprehensive analysis multi-source information and predictive models were build with 3D seismic (including regular data and attribute cubes), CSAMT data, structural geology information for hydrogeological anomaly.

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