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Research on Application of Radio Wave Perspective Technology in the Working Face of Yu Wang Coal Mine

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Abstract

Based on the Yuwang Coal Mine Working Face Detection Project of Yunnan Diandong Energy Co., Ltd., this project uses the method of wireless electromagnetic wave transmission to detect the stratum between Lane A and Lane B of a working face in Yuwang Coal Mine. This paper will study the geological structure of a certain working face in Yuwang Coal Mine, and find the fault source with a drop greater than the coal seam and the collapse column with a diameter of more than 20m in a certain working face. After the detection work of wireless electromagnetic wave transmission in the mining area, the field intensity comparison method and CT imaging method are used to process and interpret the detection data. In this paper, it is concluded that there is a fracture phenomenon of coal rock formation in this working face.

Keywords

Tomography; Radio Wave Fluoroscopy; Field Strength Contrast Method; CT Imaging Technology.

1. Introduction

In the development of the coal industry, mine safety is still an important issue in mine construction. Hidden geological disaster sources such as faults and collapsed columns will seriously affect the safety of underground construction. Faults are widely developed in coal fields, and will destroy the normal structure of the coal seam, causing the coal seam to be staggered and displaced. The coal seam is broken near the fault, and joints and fractures develop [1]. And the fault activation phenomenon caused by the mine earthquake seriously endangers the safety of the mining area [2]. The collapse column is a special collapsed fault, and it is mostly a karst collapse column in the topography of coal fields. The causes of the collapsed columns are complex and the shapes are varied. The plane shapes are mainly oval, quasi-circular, kidney-shaped, elongated and irregular. Falling columns are a great hazard in mines. The collapse pillar destroys the integrity of the coal seam, reduces the recoverable reserves, causes invalid footage, affects the driving speed, and affects the coal production [3]. To sum up, hidden disaster sources such as mine fault collapse columns are a great hidden danger to the safety production of mining areas. Combined with the characteristics of the above-mentioned fault collapse column, it can be observed by means of geophysical exploration.

At present, many scholars have done a lot of research in the exploration using the ground penetrating radar method, the seismic profile method and the transient electromagnetic method. These

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geophysical methods have their advantages in detection [4,5,6,7,8]. However, for coal seam detection between two tunnels underground, some of these methods have a short detection depth and some are difficult to construct. For coal seam detection between two underground tunnels, the most widely used geophysical detection technology is radio wave transmission technology.

Using the principle that electromagnetic waves will refract, reflect or scatter when they pass through various regular and irregular interfaces, the absorption coefficient of coal seams containing faults is greater for the absorption of electromagnetic waves. It is large, so the tomography is often abnormal in the form of high absorption strips in the CT imaging of the working face [1]. Radio wave transmission technology has the advantages of strong anti-interference ability, high-density ray superposition to improve the fineness of results [9], and portable equipment. The wireless electromagnetic wave transmission technology has good application results in finding faults and collapse columns in other mining areas [10,11], and detecting the water-bearing and water-conductivity of geological structures, and the exploration results in individual mining areas are better than other geophysical methods [12].

2. Research Background and Mining Area Geological Overview

This project is a working face detection project of Yuwang Coal Mine of Yunnan Diandong Energy Co., Ltd. In order to reasonably design the construction of the working face in the mining area and ensure the safety of the mining area, the project plans to use the electromagnetic wave transmission technology to carry out exploration work on the working face, aiming to investigate the faults in the working face whose fault drop is greater than the thickness of the coal and the collapsed pillars with a diameter of more than 20m.

Due to the karst landform features in the Yuwang coal mine field, attention should be paid to the distribution of various karst collapse columns in this karst landform [13].

3. Principle and Data Processing Method of Electromagnetic Wave Transmission Technology

3.1 Principle of Electromagnetic Wave Transmission Method

Due to the different electrical properties of various rocks and minerals, the attenuation of electromagnetic waves in the underground rock formation is also different. Low-resistance substances have a strong absorption effect on electromagnetic waves. When the electromagnetic wave front propagates to the interface containing the fracture structure, the electromagnetic wave will reflect and refract, resulting in the loss of electromagnetic wave energy. Therefore, when the electromagnetic wave passes through the coal and encounters a fault, collapse column or other geological structure in the mine, the electromagnetic wave energy will be attenuated or even completely absorbed. Therefore, faults and collapse columns in coal seams can be detected by observing the abnormal transmission of electromagnetic waves.

The underground electromagnetic wave transmission method is generally carried out in two parallel tunnels in the mining area. As shown in the figure below (Fig. 1, Fig. 2), the transmitting point is arranged in the roadway A, the electromagnetic wave transmitter is used to transmit electromagnetic waves of a certain frequency into the coal seam, and the electromagnetic wave is used at the receiving point arranged in the roadway B at the same time. The receiver observes the electromagnetic field strength H. When the electromagnetic wave propagates in each layer, when encountering the electrical change of the medium, the electromagnetic wave will be absorbed or shielded, and the received signal will be significantly weakened or no valid signal can be received. The transmitting and receiving points can be arranged in areas that are easy to pass and have little interference.

There are two methods of downhole observation: synchronous method and fixed-point method. The synchronization method (as shown in Fig. 1) is that the transmitting antenna and the receiving antenna are located in different roadways, and move at the same distance at the same time, transmitting and receiving point by point. This method is difficult to synchronize transmission and reception in the

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underground during construction, so it is rarely used. The fixed-point method (as shown in Fig.2) is that the transmitter is relatively fixed at the pre-determined transmitting point position in a certain roadway, and the receiver observes the field strength value point by point along the roadway within a certain range of the adjacent roadway. Generally, the distance between the transmitting point and the receiving point is 50m, and the distance between the receiving point is 10m. For each launch point, the receiver can observe 11 to 21 points accordingly.

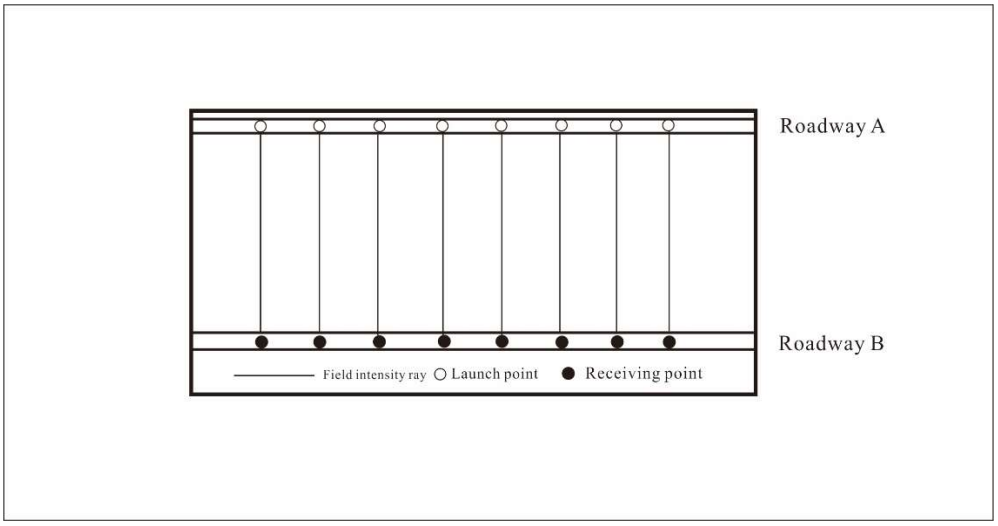

Fig. 1 Schematic diagram of transmission and reception of radio wave tunnel perspective synchronization method

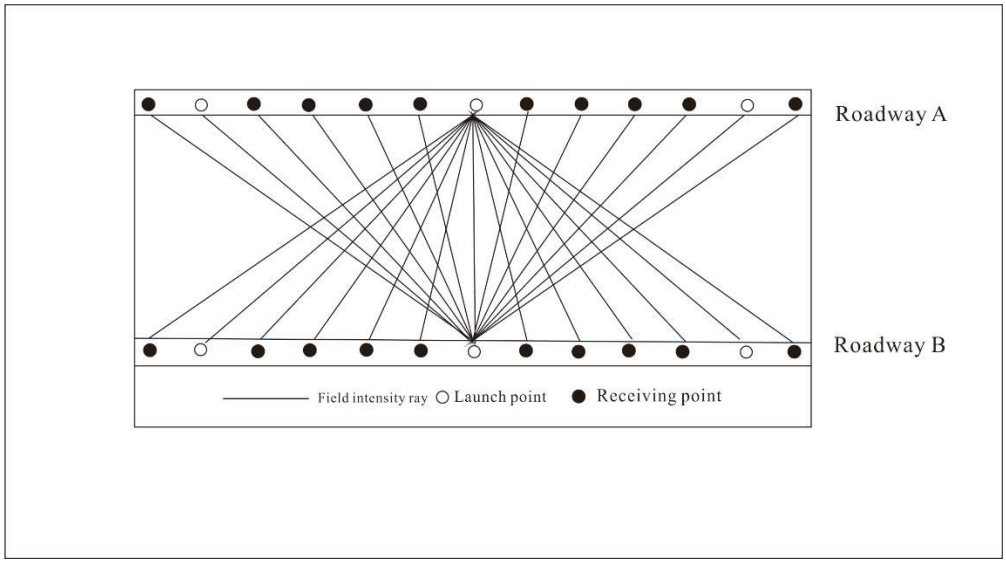

Fig. 2 Schematic diagram of transmitting and receiving radio wave tunnel perspective fixed-point method

Due to the inhomogeneity and anisotropy of the coal seam, the interference phenomenon of the secondary field and the primary field induced by the electromagnetic wave in the medium, and the reflection of the electromagnetic wave by the roadway, the field strength value observed by the electromagnetic wave signal receiver may be several waves. composite value. At this time, the abnormal area of electromagnetic wave transmission will become blurred, and it is difficult to determine the position of the abnormal body. Selecting an optimal observation frequency is very important for electromagnetic wave transmission exploration. If the frequency is too high, even high-

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resistance rocks will have obvious absorption, and as a result, it is likely that the "shadow" area of the geological anomaly to be searched cannot be highlighted, but the surrounding rock of the geological anomaly forms a "shadow" area; If the frequency is too low, the geological anomaly to be searched may be masked due to first-order diffraction. Therefore, in order to obtain the obvious electromagnetic wave transmission abnormal area, the optimal operating frequency must be selected, and the frequency used in this detection is 88KHz.

3.2 Data Processing Method

In the data processing of electromagnetic wave transmission exploration, the field strength contrast method and CT imaging method are commonly used [14].

3.2.1. Field Strength Comparison Method

The field strength comparison method is usually drawn by the method shown in the figure. Taking the point number of the receiving point as the abscissa, the measured field strength H, theoretical field strength value H0 value and attenuation coefficient η value of the receiving point corresponding to the same transmitting point are given according to the given value. The scale is drawn into a comprehensive curve diagram of the cross-section diagram, and a cross-sectional plane diagram of anomalies delineated according to the comprehensive curve diagram after each transmitting point and receiving point are calibrated on the engineering surface of the mining area. (As shown in Fig. 3).

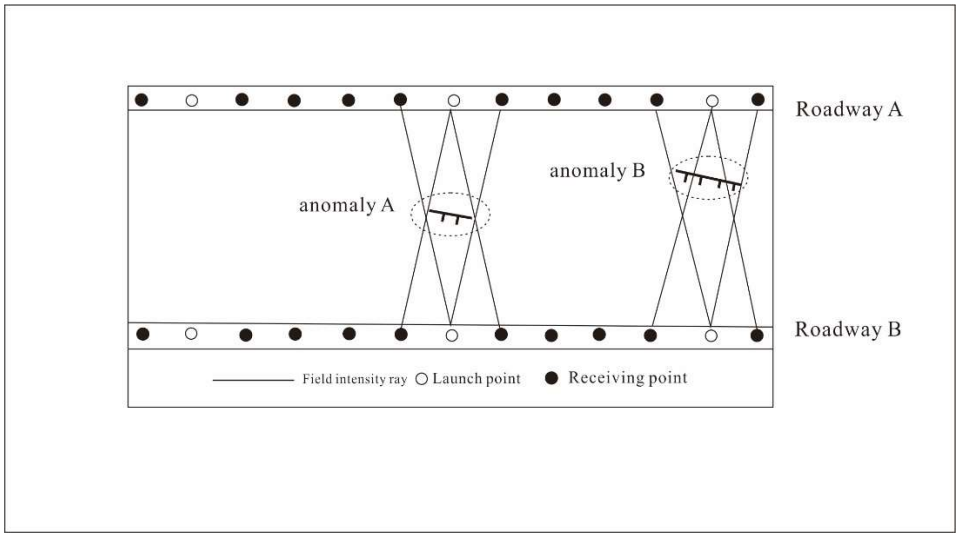

Fig. 3 Schematic diagram of interpretation of radio wave perspective curve intersection method

3.2.2. CT Imaging

The radio wave perspective method of the working face adopts a dipole antenna to transmit, and uses the SIRT algorithm (Simultaneous Iterative Reconstruction Techniques, Simultaneous Iterative Reconstruction Techniques) with the help of the field strength formula of the wireless electromagnetic wave at any point in the medium, and the calculation matrix equation can invert each pixel. Absorption coefficient value, so as to realize the inversion imaging of the absorption system in the imaging area of the working face. Using the inversion calculation results, the contour map and chromatogram of the absorption coefficient in the imaging area can be drawn [15].

4. Electromagnetic Wave Transmission Method Exploration

4.1 Detection Scheme

This time, a radio wave perspective detection with a length of 600m was carried out on the working face. The horizontal width of the incision is about 208m. The distance between the transmitting points and the receiving points is 10 meters. First, the electromagnetic waves are emitted in roadway A of the working face, and the electromagnetic waves are received in roadway B of the working face. Then,

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electromagnetic waves are transmitted in roadway B of a certain work, and electromagnetic waves are received in roadway A of the working face; this detection mission has a total of 24 transmitting points and 254 receiving points. The on-site layout of its working face is shown in the following figure (Fig. 4). The frequency of electromagnetic waves used in this exploration mission is 88KHz.

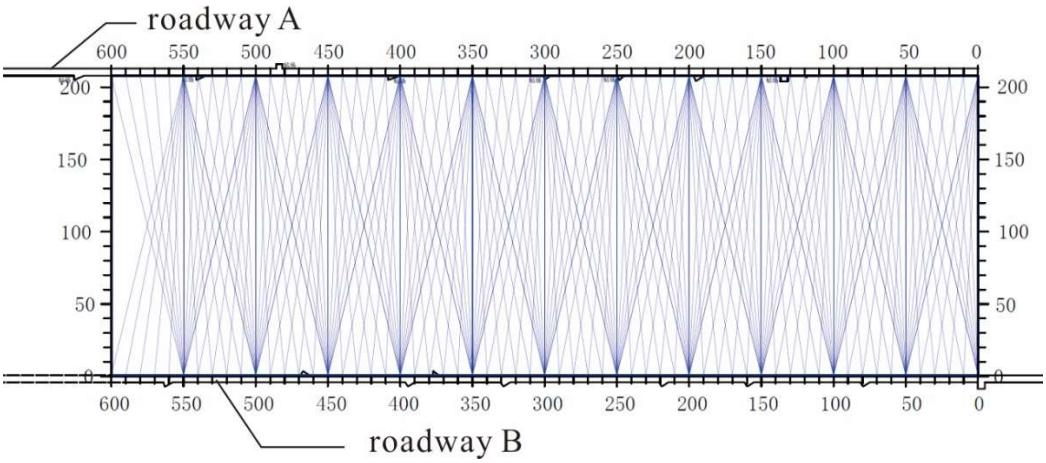

Fig. 4 Schematic diagram of on-site construction layout of the working face

4.2 Analysis of Detection Results

According to the above detection plan, we carried out on-the-spot detection on the working face of Yuwang Coal Mine. The analysis of the detection data is carried out by the radio wave fluoroscopic CT software system for inversion, and the inversion results are represented by the measured field strength curve and the measured field strength distribution. In the distribution map of measured field strength, the warm (red) tone is the large measured field strength value, and the cool (blue) tone is the small measured field strength value. Fig. 7 is an explanation diagram of the actual measured field strength of the working face by radio wave perspective detection. The darker the blue tone area is, the lower the field strength value is, that is, the radio wave penetration ability of this section of coal seam is weak. The results of each segment in the figure are basically consistent with the measured field strength curve results.

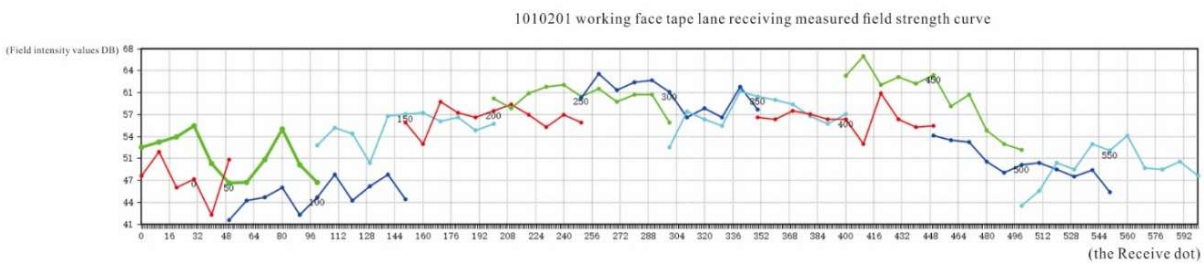

Fig. 5 the working face tape lane receiving measured field strength curve

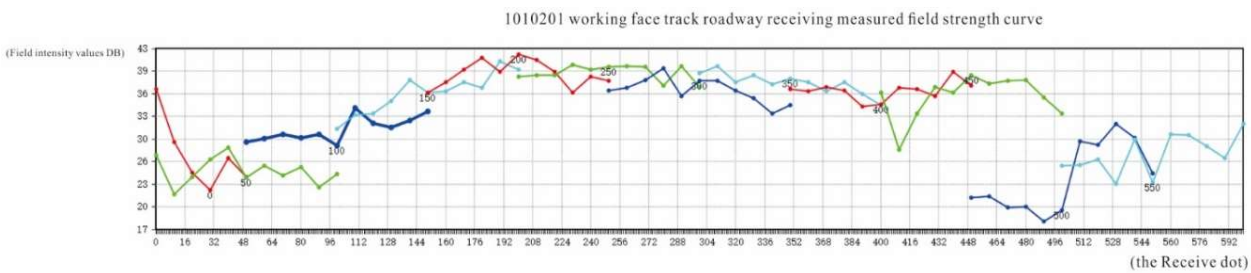

Fig. 6 the working face track roadway receiving measured field strength curve

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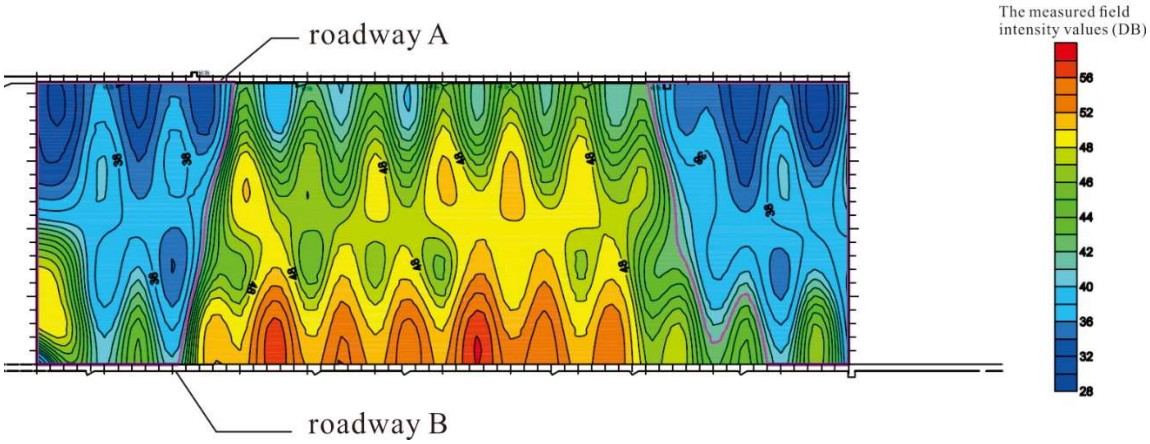

Fig. 7 Interpretation of the results of radio wave perspective measurement of field strength

Based on the analysis of the above three pictures, there is an abnormal electromagnetic wave transmission in the roadway A 0-15m at 0-60m in the roadway B. The field value here is between 20 and 32db. The smaller field value here indicates that the coal layer has a strong ability to absorb electromagnetic waves. Based on the exposure of the site and the geological data, it is judged that the fault-developed coal stratum is broken. There is an abnormal electromagnetic wave transmission at 490-600m of the roadway A 450m-600 the roadway B. The field value here is between 20 and 32db. The smaller field value here indicates that the coal layer has a strong ability to absorb electromagnetic waves. Based on the exposure of the site and the geological data, it is judged that the fault-developed coal stratum is broken. No obvious abnormality was found in other areas of the working face.

5. Summary

According to the previous geological data, the landform in eastern Yunnan is Caster landform. There are many karsts developed here, and the karst collapse columns and faults in the mining area contain fissure water. Due to the absorption effect of fissure water on electromagnetic waves, it is very suitable to use electromagnetic wave transmission technology to find geological structures such as faults and collapse columns in this mining area. By analyzing the results of this geophysical prospecting, we can intuitively find the area where the fault develops. The abnormal area of electromagnetic wave transmission in this geophysical prospecting result is clear, and the effect of using 88KHz electromagnetic wave for transmission in this mining area with more karst development is ideal.

(1) The detection results of the radio wave perspective technology in the working face of Yuwang Coal Mine have less interference. The results are clear and intuitive, and the expected detection target can be achieved.

(2) This radio wave exploration accurately found out the location of the fault in the working face of Yuwang Coal Mine. It is concluded that there is a fracture phenomenon of coal formation in this working face.

(3) Due to the thinning of the coal seam, the development of structures such as fissures and collapse columns is not conducive to the penetration of radio waves. Such anomalies generally show low measured field strength values in the measured field strength map.

Acknowledgments

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