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Detection of Underground Geological Structure by Radio-wave Laneway Penetration Technology

-- Taking F6226 of Buliangou Coal Mine as an Example

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Abstract: Hidden geological anomalies such as roof water and fault of working face will affect the mining progress and even induce coal and rock dynamic disaster. Therefore, it is necessary to use radio-wave laneway penetration meter for detection in the process of coal mining. The geological structure existing in the F6226 working face has been basically verified by this technology, which provides technical basis and support for geological work such as drilling. Through the study of the application effect of F6226 working face laneway penetration technology, and comparison with the real data revealed in the actual drilling and mining, the delineated abnormal areas in the laneway penetration results show that the abnormal areas of the 3D seismic data are verified and a collapse column is modified. The application of laneway penetration technology in mine geology improves the safety of coal mine production.

Keywords: Radio-wave Laneway Penetration; Collapse Column Perspective; Drilling and Mining Verified.

1. Introduction

Coal mining will be affected by the structure of the undiscovered working face, such as the fault below 5m and the collapse column within 20m, which has a great impact on the work efficiency and safety production of coal mining. Economic development demands more and more coal resources, increasing production will inevitably bring the demand for technological improvement, how to quickly identify the structure of the working face, to meet the demands of rapid mining has become a key issue, coal mines have also adopted a variety of methods, but there are still many problems, how to carry out transparent geological work on the working face, in front of generations of geologists. It requires our persistent efforts.

2. Detecting Time and Place

T From April 7 to 8, 2023, the YDT88 mining radio wave perspective instrument produced by Fuzhou Huahong Intelligent Technology Co., Ltd. was used to detect the geological anomalies in the underground water pressure zone (coal bottom elevation 866.3m~ cut hole section, length 670m) of F6226 working face in Buliangou Coal Industry Co., LTD, Inner Mongolia Mengtai Group. The strike length of F6226 working face with underground water pressure zone is 670m, and the inclination width is 181m.

3. Radio-wave Laneway Penetration Principle

Radio wave laneway perspective method, also known as laneway penetration method, works in a physical detection way, mainly in identifying unknown areas or geological structures of the working face. When electromagnetic wave propagates in underground coal and rock media, the attenuation degree of electromagnetic wave by rock media is different due to the differences in electrical properties (resistivity ρ, dielectric constant ε) of various rock media, ores or coal rocks. That is, when low-resistance rock encounters electromagnetic wave, it has a strong attenuation degree to electromagnetic wave. When working underground, electromagnetic waves encounter geological structures ahead, causing refraction or reflection at the interface, resulting in a certain loss of energy for electromagnetic waves. The detection principle of the pit penetration method can be analyzed to infer and interpret the coal seams, various structures, and geological bodies in the mining area based on the strength of electromagnetic wave perspective.

When electromagnetic waves propagate in coal rock layers, the intensity and phase size of the electromagnetic waves are related to various electromagnetic parameters such as the electrical resistivity, dielectric constant, and magnetic permeability of the coal rock layers. In the sedimentary sequence of coal bearing strata, the relative electrical resistivity of the overlying and overlying strata is low, and they exhibit an enhanced phenomenon when absorbing electromagnetic waves, resulting in the energy of electromagnetic wave propagation mainly concentrated in the coal rock layer medium, Radio wave perspective detection is based on this. [2] The coal seam is affected by various geological processes in the process of deposition, resulting in different parameters of coal seam medium. When radio waves pass through different positions of coal seam, the absorption of electromagnetic wave energy is different, and the medium with lower resistivity has a greater absorption degree, and the penetrating energy is attenuated. Radio wave perspective detection is carried out alternately in two lanes of fully mechanized mining face, which is transmitted from one lane and received from the other. Through data processing such as iterative inversion of double-lane alternating penetration data, CT imaging of absorption coefficient of fully mechanized mining face is formed, which provides technical support for safe mining of fully mechanized mining face.

4. Detection Purpose and Technical Requirements

According to the three-dimensional seismic detection results, the geological anomalies in the groundwater pressure zone of the F6226 working face are explained, and the geological conditions within the detection range are explained to provide a basis for the design of the next floor grouting and water blocking project. In particular, we will explore whether the DX9 collapse column exists in three-dimensional seismic interpretation (Figure 1). The three-dimensional seismic interpretation of the collapsed column is within the range of the pressure zone, and if it exists, it poses a significant hidden danger to the water inrush from the bottom plate of the Ordovician limestone. Due to the fact that the collapse column was not discovered during the excavation process of the F6226 transport channel, further confirmation is required through excavation or drilling engineering by laneway penetration or drilling engineering.

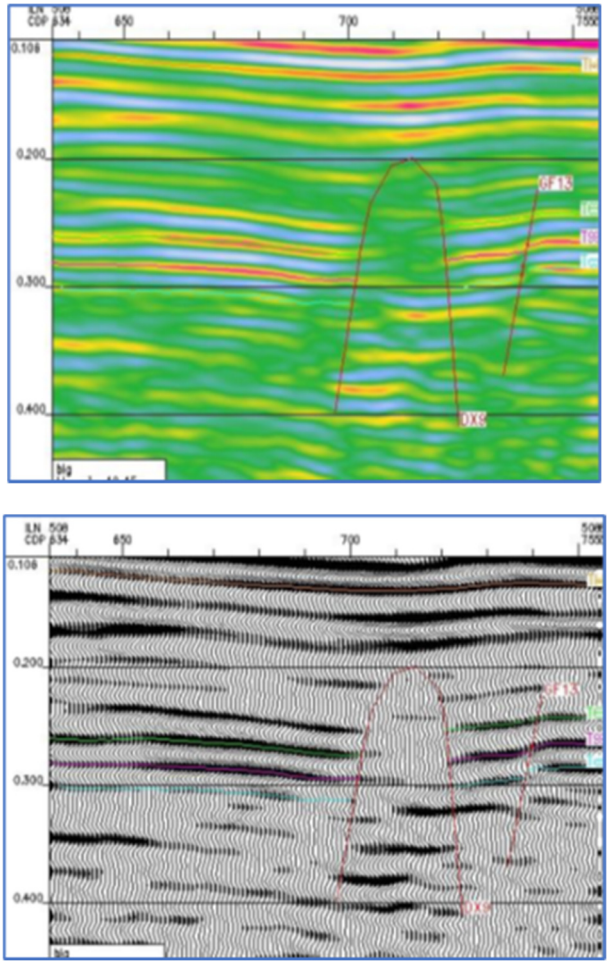


Figure 1. 3D seismic interpretation of the DX9 collapse column reflected in the time section

5. Detection Instrument, Frequency, Method and Detection Condition

5.1. Detection Instrument

The YDT88 mining wireless wave perspective instrument is a new generation wireless wave perspective instrument developed by Fuzhou Huahong Intelligent Technology Development Co., Ltd. in collaboration with relevant universities and institutes, introducing advanced digital communication modulation, high-speed sampling, embedded system and other technologies. This instrument has the characteristics of being lightweight, flexible, intelligent, efficient, with a large perspective range, strong anti-interference ability, and long battery life. (Figure 2)



Figure 2. Receiving launch system sketch map

5.2. Detection Method

The detection methods include synchronous method and fixed-point method, which are generally carried out using fixed-point method. The fixed-point method is a working method where the transmitter is relatively fixed and the receiver receives its field strength value point by point within a certain range of another corresponding tunnel; The synchronization method is a method of moving the transmitter and receiver simultaneously in two tunnels. This detection adopts the fixed-point method.

According to the actual situation of the pressure zone in the F6226 working face, the layout of the detection points for this survey starts from the intersection of the cutting eye and the roadway, and is arranged in the outer direction of the roadway in sequence, with a spacing of 10m between the measurement points. Among them, the distance between emission points is 50m, and the distance between receiving points is 10m(Figure 3). 68 detection points and 13 launch points are respectively arranged in the transportation channel and auxiliary transportation channel of the F6226 working face, with a total of 136 detection points and 26 launch points arranged. The transportation slots are numbered from 0 to 67 from the inside out, and the auxiliary transportation slots are numbered from 500 to 567 from the inside out. When the measuring points are set up and working, 3 people will launch and 3 people will receive. Each launch point will launch for 3 minutes, corresponding to 11 receiving points in the receiving section with a receiving time of 3 minutes. Moving to a different launch point will take 2 minutes. For the detection of the transportation channel in the F6226 working face, electromagnetic wave signals are emitted from point 505 of the auxiliary transportation channel, and received sequentially from points 0 to 10 of the transportation channel; After receiving, the launch point moves forward from the auxiliary transport slot to point 510 to continue the launch, and the transport slots 5-15 receive them in sequence, and so on. After the detection of the transportation channel is completed, the exchange of the transportation channel and the auxiliary transportation channel will continue until all detection tasks are completed [3].

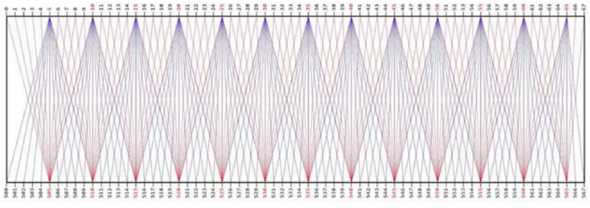


Figure 3. Receiving launch system point diagram

5.3. Detection Condition

The F6226 working face adopts anchor rod anchor mesh support for both the groove and the cut hole, and there is still a distance of 20m from the transportation groove mouth that has not been penetrated. There are ventilation and drainage pipelines, as well as transportation belt supports arranged in the tunnel. During detection, the tunnel cables were not powered off, and the belt transportation was not stopped. Interference factors such as pipelines, cables, and metal supports were not dealt with. During the detection of the auxiliary transportation channel, we encountered a rubber wheel truck transporting materials and a belt conveyor in working condition. There was local water splashing on the top plate about 200m outside the cutting eye section and cutting eye. There was water accumulation in low-lying areas on the ground, and there was water pump drainage [4].

The data collected by the penetrometer is inverted using radio wave perspective CT software, and the inversion results are represented by the measured field strength distribution map. The numerical values in the measured field strength distribution map are represented by different color scale values, with warm (orange yellow) tones indicating high field strength values and cold (blue) tones indicating relatively low field strength values. The deeper the blue tone area, the lower its field strength value, indicating that the radio wave penetration ability of the coal seam in this section is low, which is a potential structural anomaly area, as shown in Figure 4.

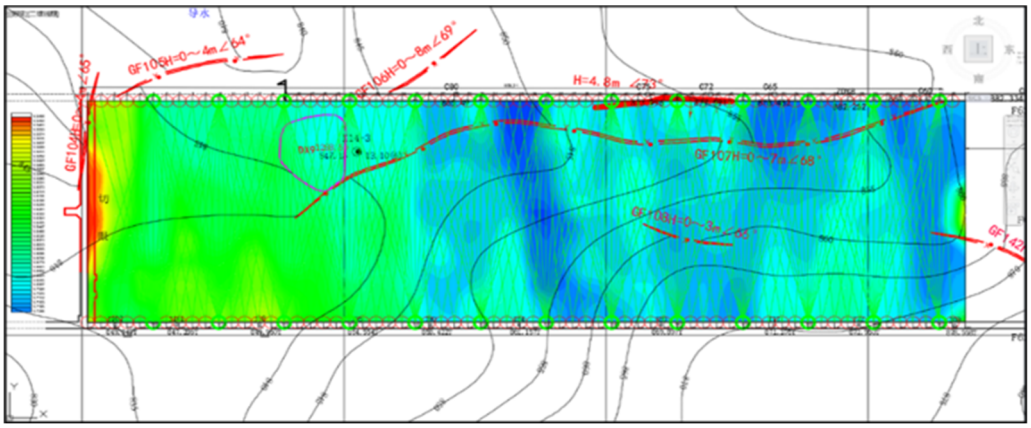


Figure 4. Plan of laneway penetration exploration results

6. Findings and Recommendations

6.1. Result

(1) No abnormalities were found within 250m of the cutting eye of F6226 working face. The DX9 collapse column adjacent to the west side of X14-3 borehole interpreted by 3D seismic exploration was not found during the exposure of the transportation channel, and no obvious anomalies in electromagnetic waves were found during this exploration.

(2) The attenuation of electromagnetic wave is obviously increased in the range of 250 ~ 670 m outward from the cut, which is explained by GF107 strike fault as a whole. GF107 fault has little influence on electromagnetic wave in the range of 160~250m, indicating that the fault drop has an obvious decreasing trend. In the range of 250~670m, the attenuation of electromagnetic wave tends to increase near the side of transportation gateway at 330m and 530m m. Because the average coal thickness in the working face with pressure is 12.05m, and it is a coal seam with complex structure, it is speculated that it may be caused by local gangue change.

(3) Since the drop of the GF108 fault is only 3m, although the composite effect of the GF107 fault is superimposed, it has little effect on the superposition of electromagnetic waves.

6.2. Suggestion

Due to the complex working environment underground and the heavy workload of each shift, electrical equipment (with local water pumps for water drainage) is running during detection. The excavation work at the cutting hole is not stopped, and the construction of workers is not interrupted, which has a certain impact on electromagnetic waves[5]. It is recommended to reduce corresponding interference factors in future detection of other working faces to ensure the accuracy of detection data and lay a necessary foundation for the interpretation of the final detection results. [6].

Special treatment is carried out for the discovered water conducting structures to prevent water damage accidents and prevent them from occurring before they occur. This provides a basis for analyzing the hydrogeological conditions of the working face, evaluating the degree of threat of bottom aquifer water to the working face, and formulating water prevention and control measures for the working face

7. Result Verification

In order to ensure the smooth progress of mining on the working face, advance exploration was used for drilling detection according to the specifications. The existence of the collapse column was not found in the 7 holes of the DX9 collapse column drilling construction. Among them, 2 were drilled in the bottom plate, and no abnormalities were found. During the mining process No collapse pillars were found, and mining has been carried out safely, which proves that the results of this tunnel penetration are relatively reliable. This detection provided a theoretical reference for the mine, and the effect was obvious and effective.

References

[1] A. M K ,David B ,R.M. J .Characterization of seepage in an earthfill dam by the integration of geophysical surveys and geotechnical data[J]. Journal of Applied Geophysics, 2024, 220105273-.W.-K. Chen, Linear Networks and Systems (Book style). Belmont, CA: Wadsworth, 1993, pp. 123–135.

[2] M C ,Ph T ,F C .On the air permeability of Populus pit. [J].Computer methods in biomechanics and biomedical engineering,2012,15 Suppl 130-1.

[3] Guo Fangyan, Liu Shiwen, Gu Song, etc. The application of comprehensive geophysical exploration in the exploration of working face structure and water rich anomalies [J]. Energy and Environmental Protection,2023,45(11):154-159+165. DOI: 10.19389/j.cnki.1003-0506.2023.11.023.

[4] Chen W ,Li W ,Hanwei Y , et al.Machine learning for layer-by-layer nanofiltration membrane performance prediction and polymer candidate exploration. [J].Chemosphere, 2023, 35014 0999-140999.

[5] Y. Z ,Z. W ,Q. C , et al.13P Efficacy and biomarker exploration of anlotinib plus penpulimab for extensive-stage small-cell lung cancer who failed previous platinum-based chemotherapy: Results from a phase II perspective trial[J].Immuno-Oncology and Technology,2023,20(S).

[6] Qiuchen L ,Fangzi C ,Xue N , et al.Investigation of Landslide by Comprehensive Geophysical Exploration in Northeast Chongqing: Taking Xiawafang Landslide as Example [J]. Journal of Physics: Conference Series,2023,2651(1).