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Application of audio frequency electric perspective technology in mine water disaster prevention

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Abstract: Based on the geophysical characteristics of the top and floor strata of No.8 coal seam in Sitai Mine, through the reasonable site arrangement of measuring points and rigorous indoor data processing and analysis, the use of audio electrical perspective technology to detect the top and floor low resistivity abnormal area in 80207 working face. According to the detection results, combined with the existing hydrogeological data of Sitai mine, the relative water-bearing area and the key water control area of the working face are delineated. The results show that the audio frequency electric perspective technology can provide a basis for the prevention and control of mine water disaster conveniently and effectively.

Keywords: Audio electrical perspective technique; Geophysical characteristics; Electrical conductivity; Data processing; Water-rich.

1. Introduction

Mine water disaster is one of the five major disasters affecting the safety of coal mine. In the prevention and control of mine water disaster, the way of drilling combined with geophysical exploration is often used to advance water exploration and release. The geophysical exploration methods include resistivity method, transient electromagnetic method and audio frequency electric method perspective. The No.8 coal seam currently being mined by four mines is affected by the top and bottom aquifers during mining. In order to eliminate the threat of water damage and ensure the normal production of coal mine, according to the actual geological situation of Sitai mine, this paper chooses to use audio frequency electric perspective technology to detect the water richness of coal seam top and floor and goaf.

2. Hydrogeological survey of mine

According to the lithology characteristics of aquifers and the occurrence conditions of groundwater in the range of Sidai mine field, the aquifers in the mine field are divided into: Cambrian limestone karst fractured aquifer, Taiyuan Formation coarse-grained sandstone fractured aquifer, Yongdingzhuang Formation bottom sandstone fractured aquifer, Datong Formation and Yungang Formation fractured aquifer and Quaternary pore aquifer. No. 8 coal seam of 80207 working face is located in the carboniferous stratum, and the main water filling source is sandstone fissure water in the roof of No. 8 coal seam and Cambrian limestone confined water in the floor. Because there are goaf of No. 14 coal seam of Datougou, No. 12 coal seam of Luojiaxin kiln and No. 14 small kiln damage area above 80207 working face, there is the possibility of goaf water inrush.

(1) Roof sandstone fissure water: Sandstone fissure aquifer is located above No.8 coal seam, and its lithology is mainly coarse, medium and fine-grained sandstone and pebbly sandstone. It is sandstone fissure water, which is the direct water filling aquifer in the roof of this coal seam. Due to the deep burial of carboniferous strata, poor recharge conditions, and limited infiltration recharge, sandstone is mostly basement and pore cementation, and the joint fissure is not developed, so the water content is weak. Simple drilling hydrology observation, no significant changes in water level in the hole and flushing liquid consumption, flushing liquid consumption within 0.10-0.20m3/h.

(2) Goaf water: The working surface of 80207 is covered with some mined-out area of Datougou No. 14 coal seam, Luojiaxin Kiln No. 12 coal seam and small kiln failure area of No. 14 coal seam. There may be water accumulation in the low lying area of the mined-out area. It may affect the safe mining of 80207 working face and even cause the flooding accident of working face.

(3) Cambrian limestone water: The Cambrian limestone is the basement of the carboniferous coal measures in Sidai Mine, and is the karst fissure confined aquifer indirectly filled with water in the coal seam floor. The lithology is mainly dark gray, gray and gray brown bamboo foliate limestone, which is interspersed with thin bedded mudstone, shale and sandy mudstone. The drilling in the well field reveals that the core is intact, and the karst form is scattered and discontinuous dissolution fissure, which is mostly filled with calcite, and the connectivity is poor. There is no obvious increase of washing fluid during drilling.

3. Principle of audio frequency electric perspective technology

3.1. Geophysical characteristics

Coal measure strata are the product of sedimentation and have obvious sedimentary sequence. There are obvious differences in electrical conductivity among different lithologic strata. Normally, coal seams and limestone have high resistance values, followed by sandstone, clay rocks have low resistance values, and water bodies have the lowest resistance values. It can be seen that there are obvious electrical differences among rocks, coal seams and water bodies with different lithologies [1~3], as shown in Table 1.

Compared with other solid media, water body has good electrical conductivity. When surrounding rock fissure or fracture zone contains water or goaf water, there are local low resistivity abnormal areas. The stronger the water content, the

lower the resistivity, the higher the conductivity, and the larger the abnormal range. The coal seam near the fault plane on both sides of the fault often has thinning phenomenon, such a zone shows relatively low resistivity, while the resistivity in the area developed in thick coal seam is relatively high [4~5]. The actual situation shows that there are obvious electrical differences between the water-rich area and the thin zone of coal seam and the normal sedimentary rock (coal) layer.

Table 1. Common rock resistivity values in common coal measure strata

Rock name	coal	limestone	sandstone	mudstone	Mine water
resistivity /Ω·m	$10\sim10^4$	$60\sim4\times10^5$	$1\sim10^5$	1~50	1~10

3.2. Audio electrical perspective technique

Audio frequency electric perspective is a direct-current dipole grounding detection technology. It is a geophysical exploration method based on the whole-space electric field distribution theory and based on the differences in electrical distribution laws of rocks and geological structures.

As a sedimentary rock series containing coal, coal measure strata have a relatively clear sedimentary sequence, and its sedimentary characteristics determine that the longitudinal conductivity shows regular changes, while the horizontal conductivity is relatively stable. When the karst and fissure in coal measure strata are filled with water and contain water, the inherent change law of the vertical conductivity of the strata and the relative stability of the horizontal conductivity will be broken. It is because of the lithology change of coal measure strata that good geophysical conditions are provided for the application and implementation of the audio electric perspective exploration [7~11]. Mine audio electric perspective is to use special instruments to observe the distribution law of artificial field sources in the mine to solve geological problems.

4. Site measurement point layout

During detection, a transmitting point is arranged every 50m in one trough, and a receiving point is arranged every 10m in the other trough to receive signals. Each transmitting point pair has 11 receiving measured field intensity points, and 21 transmitting points and 224 receiving points are arranged in lane 20207. Lane 50207 has 21 transmitting points and 224 receiving points. A total of 42 transmitting points and 448 receiving points were completed. See Figure 1 for the specific locations of transmitting and receiving points.

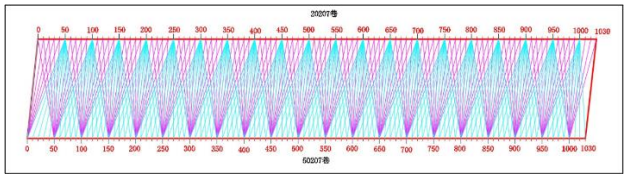


Figure 1. 80207 working face measuring point layout

5. Detection result

5.1. Data processing

With manual interpretation as the basis and computer as the tool, it is carried out step by step from coarse to fine. Through the interpretation of the trunk section, the corresponding geological horizon can be determined, and the overall occurrence form and tectonic pattern of the stratum can be mapped, which lays a foundation for the detailed interpretation of human-machine collaboration in the later period. The man-machine interactive interpretation system has special advantages in the interpretation of electromagnetic data and is an essential tool for precise interpretation. It can make full use of man-machine interface for fine interpretation of data, and has the function of keeping track, so as to greatly improve the resolution of various geological phenomena.

Electrical interpretation is combined with geological information, and the geophysical anomaly has relativity and multiple solutions. It is necessary to combine the known geological information and conduct comprehensive analysis according to the principle of from known to unknown, from point to line, from line to surface, from shallow to deep, so as to improve the reliability and accuracy of the results.

For data processing, a plane cartesian coordinate system should be established at first, with the intersection point of 80207 working face slit and transport groove as the origin, the strike of working face as the X-axis, and the direction of the inclined line of working face as the Y-axis. Coordinates should be established for each group of transmitting and receiving observation electrodes, and then CT inversion should be carried out using the given data format file. To obtain the electrical parameters of the rock (coal) layer in the working face, Surfer software was used to draw the resistivity contour map.

5.2. Processing result

Abnormal characteristics of coal seam section are shown by isoline in Figure 2, which is equivalent to the comprehensive apparent conductivity value of the coal seam section parallel to the strata near the surface of the floor of No.8 coal seam. In general, under the condition of stable stratigraphic distribution and relatively uniform lithology, the electrical property distribution is stable, and the apparent electrical conductivity isolines are evenly distributed and change gently. If there is water-bearing and water-conducting structure, the law of uniform distribution of electrical property will be broken, which is reflected in the figure as the apparent conductivity value increases, the apparent conductivity contours are distorted, deformed into traps or densely banded, etc. On the color plan, the abnormal area of high conductivity is more intuitive, showing cyan color, and the better the conductivity, the darker the cyan color, the higher the apparent conductivity value, indicating that the relative comprehensive conductivity of the stratum is better, and if it contains water, the more abundant the relative water.

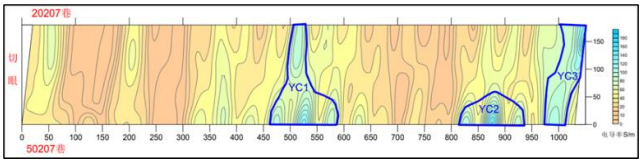


Figure 2. Electrical conductivity contour map of audio frequency electro perspective

Figure 2 shows the working face conductivity contour map. Combined with the striping regularity of the detected anomalies, the threshold of this anomaly was set at 70S/m. As can be seen from Figure 2, three abnormal areas were found in this audio electrical fluoroscopy detection. The abnormal areas were located at 460-590m, 820-940m, and 970-1030m

respectively. Their electrical conductivity was relatively high.

The electrical conductivity contour map and hydrogeological data of audio fluoroscopy were integrated to analyze each abnormal area as follows:

YC1: Between 460 and 590m away from the cut hole, this abnormal area spans the entire working face, and it is speculated that the rock layer is relatively broken and fissure developed in this range, with a certain water-rich. YC2:810 ~ 940m away from the cut hole, this abnormal area is close to the side of 50207 lane, and it is speculated that the rock layer is relatively broken and fissure developed in this range, with a certain water-rich. YC3:970 ~ 1030m away from the cut hole, this abnormal area across the whole working face, it is speculated that the rock layer in this range is relatively broken and fissure developed, and it may be related to the development of fault water conduction in this section with a drop of 3.8m, with a certain water richness.

6. Conclusion

(1) Audio electrical perspective provides a convenient and effective technical means for the prevention and control of mine water disaster in underground coal mines. However, like other geophysical exploration techniques, audio fluoroscopy has its adaptability. In practical exploration applications, we should be good at exploring and summarizing.

(2) Due to the limitation of the depth (or height) of underground electrical detection, the hydrogeological information reflected in the result data is only limited to the hydrogeological conditions within a certain depth (or height), and the mine water gushing is also related to many factors, such as recharge conditions, the development and connectivity of related water-bearing structures, water head pressure, coal seam thickness, mining method, and mining speed. With the constant change of the above factors, the mine water inflow, water inflow position and time will also change to a certain extent. Therefore, it is necessary to strengthen hydrological observation and data collection in the process of mining, and timely feedback should be given if anomalies are found, and corresponding water prevention and control measures should be taken to control them.

References

[1] Guo Pengfei, Xie Xionggang, Bai Wen, et al. Application of Audio Frequency Electric Perspective Method in Detecting Mine Flooding Zones[J]. Industrial Safety and Environmental Protection, 2018,44(4):34-36.

[2] Zhang Jun, Wang Yong, Qin Honggang, et al. The Application of Audio Frequency Electric Perspective to Detection of Coal Mine Work Face[J]. Chinese Journal of Engineering Geophysics, 2013,10(4):551-554.

[3] Yu Sen, Ji Chao. Application of audio frequency electrofluoroscopy in Qianjiaying mine[J]. Hydraulic Coal Mining & Pipeline Transportation, 2013(4):58-59.

[4] Wang Jianjun. Application of audio frequency electric perspective in fully mechanized coal mining face[J]. China Mine Engineering, 2008,37(2):36-38.

[5] Li Dan, Han Depin, Shi Yading, et al. Electric detection method of coal seam perspective along coal face[J]. Journal of China Coal Society, 2010,35(8):1336-1340.

[6] Jin Jingyu. Application of audio frequency electric perspective technology in the prevention and control of coal seam roof water[J]. Shandong Coal Science and Technology, 2014(7):163-165.

[7] Zhou Xiaolong, Chen Guojun,. Application of audio frequency electric perspective method in limestone water detection of working face in Huainan Coal Mine[J]. Coal Science & Technology Magazine, 2017(1):92-94.

[8] Gao Zhihong, Wang Yanhong, Chen Qingfeng. Detection of rich water area in working face and mine electric method — Application effect of audio frequency electric perspective in detecting rich water area in working face[J]. Coal Geology & Exploration, 2002,30(4):51-54.

[9] Li Donglin, Jiang Zhenquan, Yang Dongliang. Water resistance condition of coal seam floor reflected by audio frequency electroscopic detection results[J]. Journal of Earth Sciences and Environment, 2005,27(3):68-71.

[10] Wu Chaofan, Qiu Zhanlin, Jin Qizhong. Analysis of transient electromagnetic water exploration effect in limestone roadway [J]. Mining Safety & Environmental Protection, 2013,40(5):67-70.

[11] Li Bing. Application of advanced detection technique of direct current method in detecting water-bearing fault structure[J]. Coal Technology, 2015(3):113-115.

[12] Zhou wenlong. Comparative analysis of three geophysical exploration methods for water damage in working face floor[D]. Huainan: Anhui University of Science and Technology, 2017.

[13] Feng Bo, Liu Lin. Application analysis of transient electromagnetic technology in coal seam roof water prevention[J]. Jiangxi Coal Science & Technology, 2017(1): 36-38,42.