Discrimination and application of the properties of the in-seam seismic wave in the collapse column of the working face

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Abstract. During in-seam wave seismic exploration of working face, the anomaly has serious diversification, and sometimes it is difficult to accurately determine the nature of the anomaly. Due to the large differences in the collapse column shape of the working face, especially when there are multiple sets of collapsed columns, it is difficult to effectively distinguish its nature. This has been an unresolved problem since the tunnel wave earthquake was introduced. Based on the analysis of the characteristics of the collapse column in the working face, the forward simulation analysis of the collapse column is carried out. Based on the field application case, the BPT algorithm and the SIRT algorithm in the calculation process of the energy attenuation coefficient tomography overlay inversion calculation are studied. Through analyzing the amplitude and frequency dispersion characteristics of the verification of the collapse column anomaly, a method for identifying the seismic properties of the working face collapse column groove wave is proposed, which effectively improves the accuracy of the in-seam wave seismic detection.

1. Introduction

During in-seam wave seismic exploration of working face, the anomaly has serious diversification, and sometimes it is difficult to accurately determine the nature of the anomaly. Due to the large differences in the shape of the working face collapse column, especially when there are multiple sets of collapsed columns, it is easy to cause faults and broken geological bodies during interpretation. Such confusion makes it difficult to effectively distinguish its nature[1]. This has been an unresolved problem since the tunnel wave earthquake was introduced into the downhole structure. Therefore, it is necessary to study the influence law of in-seam wave seismic excitation and reception conditions and the characteristics of the attenuation coefficients of different geological anomalies, to realize the effective anomaly identification of in-seam wave seismic and the discrimination of the nature of the geological anomaly, and to reduce the falsehood caused in the process of data acquisition and processing. Anomalies have great field application value for improving the accuracy of anomalous nature discrimination[2].

In this paper, based on the analysis of the characteristics of the collapse column in the working face, the forward simulation analysis of the collapse column is carried out. Based on the field application case, the two algorithms (BPT algorithm and SIRT algorithm) in the calculation process of the tomographic
overlay inversion of the energy attenuation coefficient are studied. Through the analysis of the amplitude and dispersion characteristics of the verification of the collapse column anomaly, a method for identifying the seismic properties of the working face collapse column groove wave is proposed, which effectively improves the accuracy of the in-seam wave seismic detection.

2. Analysis of the characteristics of the collapse column in the in-seam wave seismic exploration

When there is a collapse column in the working face, after the tunnel wave signal propagates to the edge of the collapse column, it is no longer restricted by the roof and floor of the coal seam to form total reflection, the seismic signal spreads outward, and the energy is significantly attenuated[3].

When the size of the collapse column is small (generally less than 30m in diameter), part of the tunnel wave signal can be transmitted and diffracted to the opposite roadway, and the energy attenuation is relatively small; when the collapse column is large (generally greater than 50m in diameter), the energy attenuation is very obvious, generally unable to receive effective tunnel wave signal. The collapse column generally also presents an elliptical anomaly on the attenuation coefficient cloud map (see Figure 1, the red area is the abnormal area). The surrounding coal and rock mass affected by the collapse column sometimes develops with broken areas, which leads to the expansion of the abnormal range [4].

Figure 1. Schematic diagram of characteristics of falling column attenuation coefficient.

In order to theoretically study the attenuation characteristics of collapse columns, a theoretical model of three collapse columns with a diameter of 30m was established and forward simulation analysis was carried out[5]. Through forward modeling and CT imaging analysis of the attenuation coefficient, it can be seen that the overall shape of the collapsed column is ellipsoid-like, the abnormal range is slightly larger than the distribution area of the collapsed column, and the attenuation characteristics are obvious.
3. Application case of identification of in-seam wave seismic properties of the in-seam seismic wave in the collapse column of the working face

3.1. Overview of case

The working face 4323 of Changping Mine of Shanxi Jincheng Anthracite Mining Group Co. Ltd. has a strike length of 526.71m and an inclined length of 135.7m. The average thickness of the coal seam 3 is 5.84m, which is a stable mineable coal seam.

This survey adopts the transmission in-seam wave seismic method, and the survey line length is 625m. The specific plan is as follows: a total of 42 detector holes (arranged in Lane 43231, with a distance of 15m) and 45 blast holes (arranged in the working face 4323 and Lane 43232, with an interval of 20m and 15m respectively).

In view of the characteristics of this tunnel wave data, the energy attenuation coefficient is finally selected for tomographic imaging. In the process of stacking inversion calculation, the BPT algorithm and the SIRT algorithm are used for imaging respectively, and a total of 7 abnormalities are delineated. (In the groove wave energy imaging diagram, the warm color area represents the abnormal area with strong energy attenuation; the abnormality of the BPT algorithm is: a, b ... f, and the abnormality of the SIRT algorithm is A, B ... F)[6].
3.2. Results verification analysis

According to the results of the return visit, the YC2 area corresponds to the actual exposed position of the collapsed column. The inferred area is slightly larger than the actual exposed position and can surround the actual position of the collapsed column. The rest of the abnormal area does not expose the geological structure such as collapsed columns or faults. Considering the accuracy of geophysical exploration methods, it is considered that the detection result is accurate, but in order to further improve the accuracy of the in-seam wave detection, extract and verify the accurate area and verify the non-structural area rays and perform single shot data analysis[7].

YC1, YC3, YC4, YC5, YC6, YC7, no actual disclosed structure.

The amplitude and dispersion characteristics of the areas that have been exposed and verified as collapse columns are analyzed. At the positions of the exposed collapse columns, that is, the 8th guns 3-8 channels, the 9th guns 3-9 channels, the single shot records have obvious Airy phases. Compared with other seismic trace data, it shows obvious weak anomaly characteristics[8].
It can be seen from the dispersion curve of the data of each channel of the 8th guns that the obvious trough wave Airy phase can be observed on the whole from the second to the 10th channel. The main frequency range of the Airy phase is 100Hz~800Hz, which shows that the trough wave in this area relatively developed; the fourth and sixth channels, except for low-speed signals between 600Hz and 800Hz, the high-speed signals have strong energy, and each wave velocity has energy distribution; the fourth and sixth channels are between 100Hz and 250Hz Airy The phase jitter is obvious, there is a local transmission energy distribution in the speed range of 1000m/s~1500m/s between 200Hz~500Hz; the 7th channel has a more obvious first-order Airy phase between 420Hz~800Hz; the 8th channel There is a local transmission energy distribution in the range of 1000m/s~1500m/s between 350Hz and 600Hz. From the known geological exposure, it can be seen that the second, third, ninth, and tenth seismic rays did not pass through the collapse column, and the Airy phase was generally smooth and continuous, which was more consistent with normal stratigraphic characteristics. The analysis shows that, except for the YC2 area abnormalities, other abnormalities are not caused by the collapse column[9].

4. Conclusions
When there is a collapse column in the working face, the energy of the tunnel wave signal will be significantly attenuated after propagating to the edge of the collapse column. When the size of the
collapse column is small (generally less than 30m in diameter), part of the tunnel wave signal can be transmitted and diffracted to the opposite roadway, and the energy attenuation is relatively small; when the collapse column is large (generally greater than 50m in diameter), the energy attenuation is very obvious, generally unable to receive effective tunnel wave signal. Affected by the collapse column, the surrounding coal and rock masses are sometimes accompanied by the development of broken areas, resulting in the expansion of the abnormal range.

Both the BPT algorithm and the SIRT algorithm of energy attenuation coefficient tomography stack inversion calculation can effectively interpret structural anomalies such as in-seam wave seismic detection of collapsed columns. Due to the existence of multiple solutions, the interpretation accuracy of structural anomalies such as the collapse column of the working face can be improved by means of analysis of amplitude and dispersion characteristics and field verification.

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