Aquifer Variation Characteristics of Coal Overlying Strata by Time-lapse Resistivity Monitoring

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Abstract

The coal mining areas of Western China are facing serious shortage of water resources and fragile ecological environment, high-intensity coal mining results in ground subsidence and overburden destruction, the structure of underground aquifer is destroyed and the groundwater level is lowered. The time-lapse electric prospecting method is applied to dynamically monitor the underground aquifers in different periods of modern coal mining. Time-lapse resistivity monitoring carries out multiple 2D electric prospecting for the same stratum at certain time intervals. Time-lapse resistivity monitoring involves many aspects such as data acquisition, processing, interpretation and inversion. The research district is located in Shendong mining district in Shaanxi Province. 4 times resistivity data acquisition is determined, the time node respectively is pre-mining, mining and post-mining as well as post-mining deposition stable period, the duration of this time-lapse data acquisition is 10 months. The research result shows that the aquifer variation of overlying strata have self-recovery capability with the development of modern coal mining process, the self-recovery capability gradually strengthens from coal seam roof upward to the near surface, the self-recovery capability of near-surface strata is relatively strong , while the roof of coal seam is most weak.

Keywords: aquifer, coal, overlying strata, time-lapse, resistivity, monitoring

Introduction

The coal mining areas of Western China are facing serious shortage of water resources and fragile ecological environment, high-intensity coal mining results in ground subsidence and overburden destruction, the structure of underground aquifer is destroyed and the groundwater level is lowered. It will not only cause the contradiction between the supply and demand of water, but also bring a certain effect to the ecological environment. The time-lapse electric prospecting method is applied to dynamically monitor the underground aquifers in different periods of modern coal mining, in order to research the influence of coal mining on overlying aquifer and groundwater.

Time-lapse resistivity monitoring carries out multiple 2D resistivity prospecting for the same stratum at certain time intervals, in order to study the temporal-spatial variations of aquifer characteristics of overlying strata. Time-lapse resistivity monitoring involves aspects such as data acquisition, processing and interpretation and inversion.

Research area overview

The research district is located in Shendong mining district in Western China's Shaanxi Province. The strata of mining area from old to new have Yanchang Formation of Upper Triassic (T3y), Fuxian Formation of Lower Jurrasic (J1f), Yan'an Formation of Lower-Middle Jurrasic (J1-2y), Zhiluo Formation of Middle Jurrasic (J2z) and Cenozoic sediments (Q).

The strata of mining area are generally monocline strata dipping into west with a dip angle of about 1-3°, where faults are rare and structure is simple. The thickness of bed rock is 180-200m and that of unconsolidated formation is 10-25m.

The mined coal seam of 12407 working face in mining area is Coal 1-2, of which the depth is 190-220m, the average thickness is 4.81m and the dip angle is 1-3°, and the coal seam is stable as well as the structure is simple.

12407 working face stope uses approach of full-seam mining, longwall mining and caving type roof control, in which the mining height is 4.5m, working face length is 300m, the footage is 3600m, the average daily mining footage is 12-13m and the monthly total footage is 390m-400m.

Aquifers monitoring principle

The resistivity of the underground stratum is not only related to the physical characteristics and water content of the stratum, but also closely related to the structural state and deformation and destruction of the stratum. The resistivity of the rock layer increases with the increase of the degree of rock failure in the case of the rock layer is not hydrated. The resistivity of the rock layer varies with its water content, the higher the water content of the same rock layer is, the lower the resistivity, the apparent resistivity of the overlying strata changes before and after the coal seam mining, and the electric property is different with the change of coal seam and strata caused by mining failure and different water content. Therefore, resistivity parameters are used to identify water abundance and its variation under different mining conditions of overlying strata.

Time-lapse resistivity data acquisition method

Time-lapse resistivity monitoring studies aquifer variation of overlying strata in coal mining through repeated resistivity prospecting at different time periods. Data acquisition is chosen to be carried out in different phases of coal mining, i.e. performed before mining, during mining and in deposition stable period after mining respectively. The duration of this time-lapse data acquisition is 10 months, the working footage positions corresponding to data acquisition time are shown in Figure 1.

The first acquisition started when Coal 1-2 of 12407 working face hadn't been mined and the coal seam was in original state, and the acquisition was background survey for strata. The second acquisition was carried out 4 months later, when nearly half of Coal 1-2 of 12407 working face had been mined, and half area of the working face was goaf and the other maintained unmined. Strata of goaf was in mining state and coal seams adjacent to the mining area would be influenced by mining while coal seams that were far away from the mining area maintained unmined. The third acquisition was conducted 2 months later, when Coal 1-2 of 12407 working face had been totally mined up, and the working face became a goaf completely and the strata were in mining state.The fourth acquisition was then implemented 4 months later, when strata of 12407 working face was totally in post-mining deposition stable period.

Resistivity discrepancy analysis during coal mining

The resistivity profile is obtained through the inversion of the apparent resistivity of the collected data, and the 3D data cube is formed by using the visualization image of multiple line data. The resistivity distribution of the aquifers is obtained by the target layer subdivision of the 3D data cube, and the water bearing capacity of the overburden aquifer and the water bearing change law of the coal seam under the influence of the mining are analyzed.

Figure 2 shows geoelectrical profiles derived from processing those 4 acquired resistivity data.

According to the geoelectrical profile of first acquisition, 3-4 resistivity strata are distributed in the underlying strata of surface; the surface has one relatively high-resistivity thin bed and 20-30m underneath, there is one inhomogeneous low-resistivity stratum, of which the inhomogeneity is mainly influenced by topography or subsurface hydrogeological conditions; generally, the bed rock section has the resistivity distribution of coal measure strata and the roof bears water in some local areas.

On the profile of second acquisition, 4-5 resistivity strata are distributed in the underlying strata of surface, the resistivity of surface sand zone fluctuates locally, the zone 20-30m below surface generally shows a resistivity distribution of low-resistivity stratum; Influenced by working face mining, the resistivity of coal roof fluctuates locally and the local resistivity of areas near mining working face increases.

On the geoelectrical profile of third acquisition, 4-5 resistivity strata are distributed in the underlying strata of surface, the resistivity of surface strata increase relatively, the zone 20-30 below surface generally shows a resistivity distribution of low-resistivity stratum; the resistivity of coal roof influenced by working face mining fluctuates locally.

On the geoelectrical profile of fourth acquisition, 4-5 resistivity strata are distributed in the underlying strata of surface, the resistivity of strata located in the middle of survey lines is relatively higher and the sand and soil are relatively dry. The zone 20-30m below surface generally shows a resistivity distribution of low-resistivity stratum with inhomogeneous thickness; The resistivity of coal roof fluctuates, which indicates the water content of water-bearing sandstone strata of roof decreases, which may be resulted from water charging of goaf.

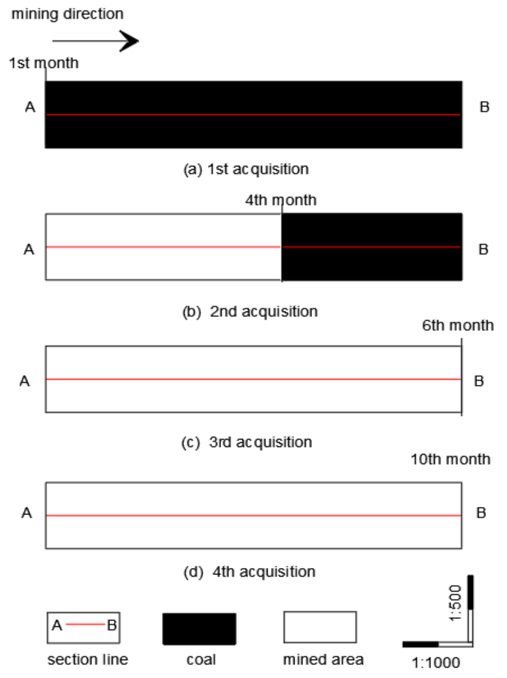

Figure 1 Working face footage position

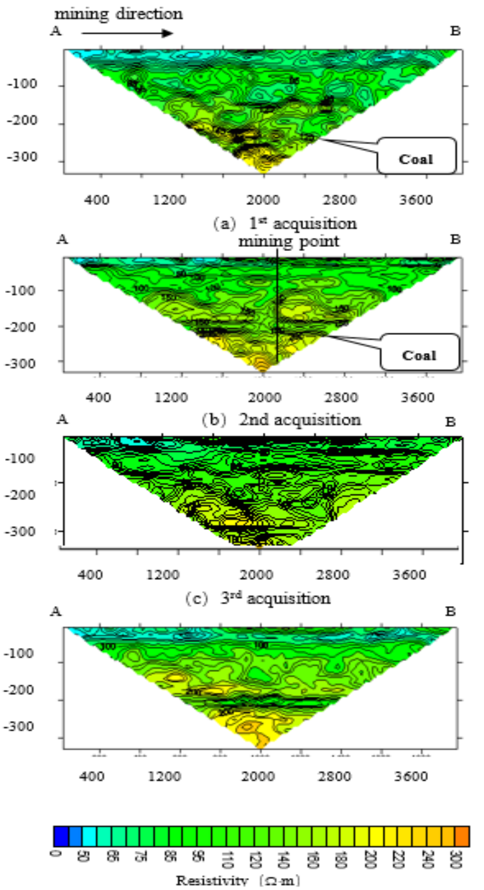

Figure 2 Geoelectrical l profiles comparison

Shallow aquifer variations during coal mining process

Within the research area, those surface water-bearing formations with a depth of 15-50m are called shallow aquifer. It can be found through comparing resistivity slices (Figure 3) of shallow aquifer during coal mining that before mining, due to a small brook exists in the middle of shallow aquifer (Fig.3(a)), its underlying strata are water saturated and water bearing of other zones is poor; during mining (Fig.3(b) and Fig.3(c)), mining activities lead to electric property changes of subsurface aquifers, the resistivity increases a little bit and water bearing deteriorates in general; during post-mining deposition stable period (Fig.3(d)), resistivity of subsurface aquifer decreases and its water-bearing distribution basically recovers to the pre-mining state.

Aquifer variations of coal roof during coal mining process

Figure 4 shows the resistivity slices of roof aquifer during coal mining. It can be found

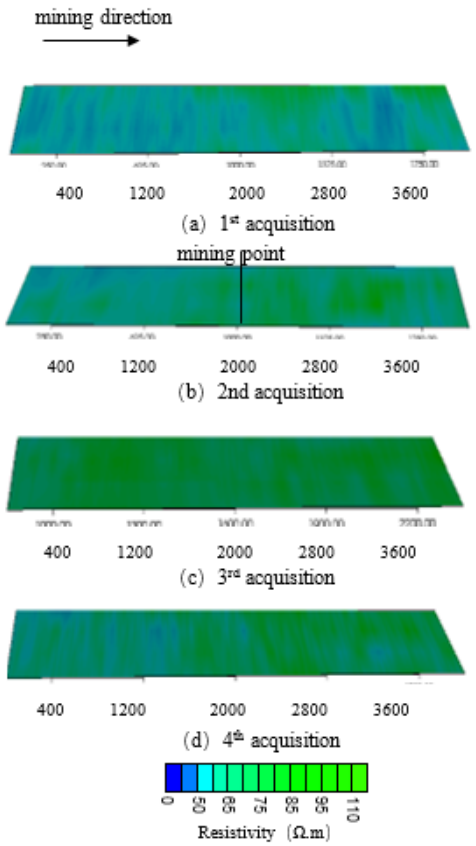

Figure 3 Resistivity slices of shallow aquifer

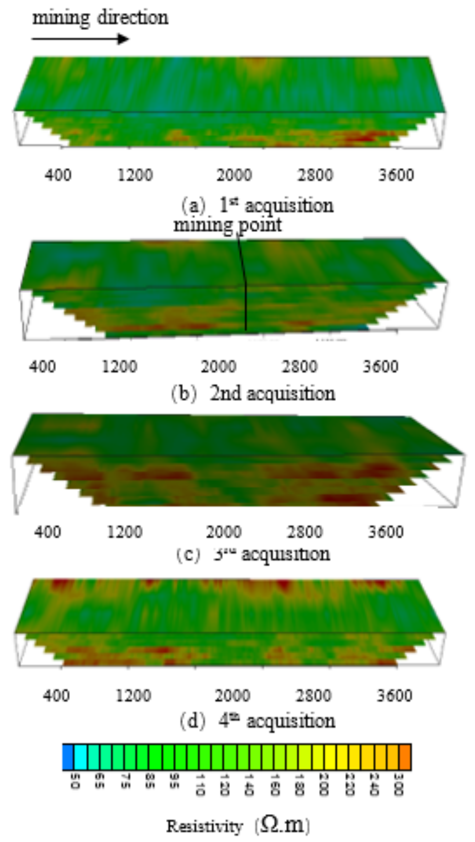

Figure 4 Resistivity slices of coal roof aquifer

through comparison that before mining, the roof has multiple inhomogeneous aquifers (Fig.4(a)), of which the local water bearing is good; when influenced by mining (Fig.4(b) and Fig.4(c)), roof water infiltrates downward and roof resistivity increases, the water bearing of roof aquifer deteriorates, after post-mining deposition stable period, water bearing of roof doesn't recover (Fig.4(d)) and generally is poor.

Conclusions

Influenced by coal mining, resistivity of shallow aquifer increases in the mining process, in post-mining deposition stable period, local ground water of the aquifer infiltrates, resistivity decreases, and its water bearing basically recovers to the pre-mining state. Water bearing of coal roof become worse during mining. This indicates that water bearing self-healing capability of shallow strata is higher, while that of roof strata adjacent to the coal seam mined is lower.

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References

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