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ORIGINAL ARTICLE

Simulation of water resource loss in short-distance coal seams disturbed by repeated mining

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Abstract Physical simulations and field measurements were performed to study the movement of overlying strata and water conductive fractures (WCF) under conditions of repeated mining in short-distance coal seams. In addition, the feasibility of water resource conservation mining (WRCM) was analyzed in areas disturbed by repeated mining. The results of the simulation showed that the aquiclude remained intact after the mining of Coal Seam 11 (the 1st main seam) in Shigetai coal mine in northwest China. According to the findings, WRCM can be conducted in this area. After the mining of Coal Seam 12 (the 2nd main seam), the WCF in overlying strata above the central section of the mined-out area will gradually compress and close. However, due to the impact of repeated mining in short-distance coal seams, WCF in overlying strata at the edge of the mined-out area are connected to the Quaternary loose aquifer and are not likely to close, resulting in the loss of the water resource. Thus, WRCM in this area would be difficult to conduct. Moreover, field observations showed that the aquifer can likely remain intact after Coal Seam 11 is mined, but the aquifer's water level will probably not fully recover if Coal Seam 12 is mined. This is consistent with the simulation results. Therefore, appropriate technical mining measures must be taken to conduct WRCM at the 2nd main seam in the shallow-buried short-distance coal seams. These research results can be used as a reference for future WRCM endeavors in the arid and semi-arid regions of northwest China.

Keywords Short-distance coal seams · Repeated mining · Water conductive fractures · Water resource conservation mining · Physical simulation

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Introduction

The arid and semi-arid regions of northwest China are ecologically vulnerable environments that lack natural water resources. The problem is made worse by environmental disruption, and resource exploitation, and coal mining operations (Booth 2006; Maximovich and Khayrulina 2014).

Technological advancements in water resource conservation mining (WRCM) are ecologically significant in China, and WRCM technology was applied during the exploitation of the 1st main seam in the western shallow-buried coalfields. Some mines have adopted coordinated methods of coal mining and water resource conservation to protect the surface environment and underground water resources (Bian et al. 2012; Zhang et al. 2010). However, due to mining constraints, studies have only been conducted on single seams (the 1st main seam), and no research has been conducted in respect to WRCM and its feasibility in the conditions of repeated mining in short-distance coal seams (Ma et al. 2013; Zhang and Shen 2004).

Based on the actual geological conditions of Shigetai coal mine in the Shendong mining area of northwest China, this paper analyzed the development process and evolvement of mining-induced water conductive fractures (WCF) in areas disturbed by repeated mining in short-distance coal

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seams. It subsequently researched the feasibility of WRCM under these geological conditions, providing a reference for potential WRCM in shallow-buried short-distance coal seams in the future (Zhang et al. 2013).

Coal seam occurrence conditions and hydro-geological characteristics

Coal seam occurrence and longwall face conditions

Located in Shenmu County in Shaanxi Province, the Shigetai coal mine has a production scale of 10 Mt/a in the primary mineable coal seams of Coal Seam 11 and Coal Seam 12, which are located in the center of the fifth section of the lower and middle Jurassic Yan'an Formation. The average thicknesses of Coal Seam 11 and Coal Seam 12 are 2.1 and 2.7 m, respectively, and the average depths are 78.1 and 100.2 m, respectively. The average interval between two seams is approximately 20 m.

Longwall Face 11105 is being excavated in Coal Seam 11, with a strike length of 1000 m, a dip length of 300 m, and a mining height of 2.5 m. Longwall Face 12105 is being excavated at Coal Seam 12, with a strike length of 1300 m, a dip length of 300 m, and a mining height of 2.7 m. The end of the open-off cut for Face 12105 is approximately 10–20 m internally removed from that of Face 11105, and the air-return roadway for Face 12105 is approximately 50 m removed externally from that of 11,105.

Two hydrological observation points (Hole 1 and Hole 2) are positioned on these two faces to conduct observations on the variation of the aquifer water level, as shown in Fig. 1. The column of observation holes is shown in Table 1.

Hydro-geological characteristics

The main aquifers in the coal mine are Quaternary loose aquifers. Under this, a loess layer and highly weathered fine sandstone strata make up the aquiclude.

Physical simulation and experimental design

After the simulation mining of Coal Seam 11 and Coal Seam 12, the development process and evolvement rule of WCF was obtained to determine whether WRCM could be conducted in the area disturbed by repeated mining. Based

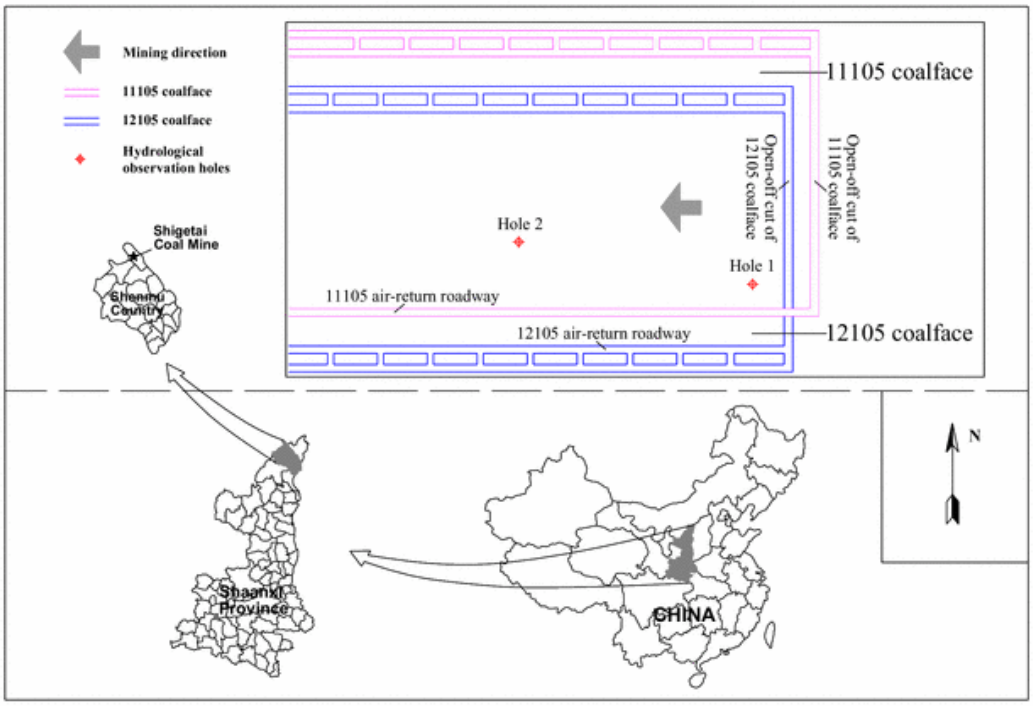

Fig. 1 Layout of water level observation holes

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