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# Technical scheme and application of pressure-relief gas extraction in multi-coal seam mining region

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ABSTRACT

A pressure relief gas extraction technical model of a typical mining area is proposed based on coal and gas simultaneous extraction theory. Flac$^{3D}$ was employed to model vertical stress and displacement contour plot characteristics of non-outburst coal seam (No. 4) on top of outburst coal seam (No. 2) along strike and incline directions. Field investigations were also conducted to verify the scientific nature of the simulation. The results demonstrate that gas pressure in No. 2 coal seam dropped to approximately 0.55 MPa in the pressure relief multi-coal seam. The highest expansion rate of the coal mine reached up to 2.58%. The pressure-relief angle was 76° along the incline direction and 60° along the strike direction. As the expansion rate and pressure-relief angle increased and the gas pressure decreased, a large amount of gas flowed into the gob of No. 4 from No. 2 coal seam and was later discharged through specific gas pipes, which eliminated No. 2 outburst risks. This study resulted in positive outcomes in that gas extraction time was reduced by 13.5 days, due to pressure relief, and drilling work load was reduced by 0.1161 m/t coal. This method ensures that gas is discharged from the outburst coal seam quickly and safely, demonstrating that the proposed technical model of pressure-relief gas extraction is effective in a multi-coal seam region.



## 1. Introduction

The application of protective mining and gas extraction technology not only reduces the risk of coal and gas outbursts from protected coal seams, but it also allows for simultaneous extraction of coal and gas in coal seams that have high risks of outburst. Protective seam mining and gas extraction technologies are widely used in practice [1–6] and combined with the above technologies they are effective for high-efficiency, safe mining of coal and gas resources.

Many cases of theoretical research and technical applications have been undertaken recently by researchers [7–12]. Liu et al. [13] adopted the analogy simulation method to study the dynamic evolution laws of overlying fractures induced by mining in the protective seam and the protective scope of pressure relief. By using FLAC$^{3D}$ or RFPA software, Shi [14,15] investigated the stress levels of coals and rocks around the protective seam in the driving process and analysed the characteristics of pressure-relief protection. Cheng [16–19] studied the techniques of continuous pressure relief for mining protective seams, protective scope expansion for pressure relief and evolution laws of gas permeability in protective seam mining processes [20–23].

Pressure relief gas extraction in coal seam mining groups is a systemic engineering practice based on the interactions of mining-influenced stress fields, fractures and gas flow fields. However, research is limited because of the current, unreasonable model of pressure relief gas extraction, which requires extensive practical data to form a solid foundation [24]. In this study, the geological conditions of gas occurrence in non-outburst coal (No. 4) and outburst coal (No. 2) were investigated. The relevant mathematical model was calculated using FLAC$^{3D}$. The distribution characteristics of the stress field, displacement field and the gas pressure of overlying rocks were studied. Meanwhile, the effects of pressure relief and increased permeability from coal seam No. 4 to No. 2 were studied and the result were compared with field applications.

## 2. Pressure-relief gas extraction under multi-coal seam extraction conditions

During coal seam group mining, simultaneous coal exploitation causes extra fractures, deformation or subsidence of the overlying coal and rock. As mining-induced fractures develop, the permeabil-

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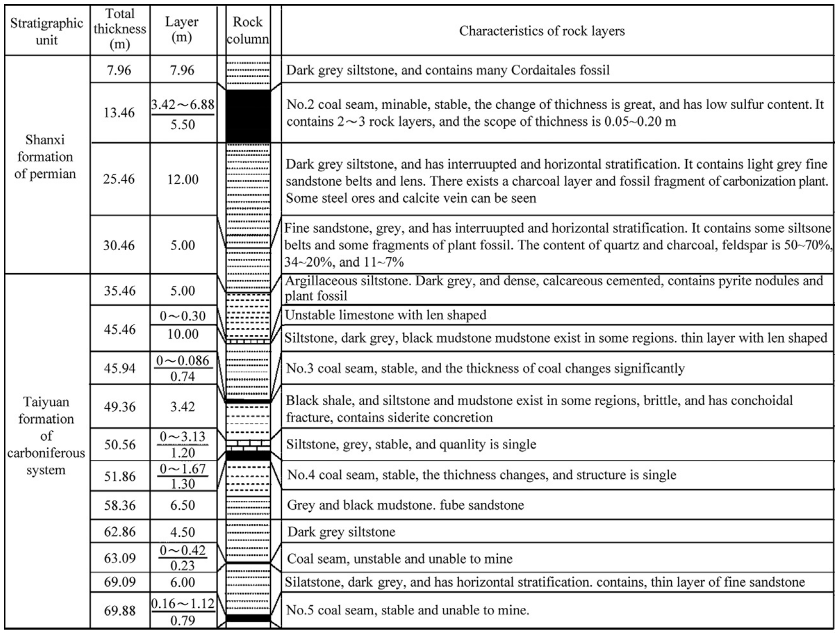


**Fig. 1.** Coal measure strata histogram of the studied coal mine.

ity of the coal seam increases, allowing for coal seam gas to be drained more efficiently and continuously, which ensures safe and effective production of the coal mine [25–26]. Aiming to exploit coal and gas in the first mining and adjacent seams, time and space must be considered to achieve a balance between drainage, driving and mining.

The coal bearing formations that were studied include the Middle Carboniferous Benxi Formation, the upper Taiyuan formation and the upper Taiyuan formation of the lower Permian series in the Shanxi Formation. The average thickness of No. 2 and No. 4 coal seams are 6.0 m and 1.25 m, respectively. The stratigraphy of the coal mine is shown in Fig. 1.

In the process of roadway advancing, a coal and gas outburst occurred in No. 2 coal seam. No. 4 coal seam has a low outburst risk since the gas pressure and gas content is low. Because No. 4 coal seam is close to No. 2 coal seam, No. 4 coal seam was chosen as the first mining seam. The pressure-relief gas extraction technical model is shown in Fig. 2.

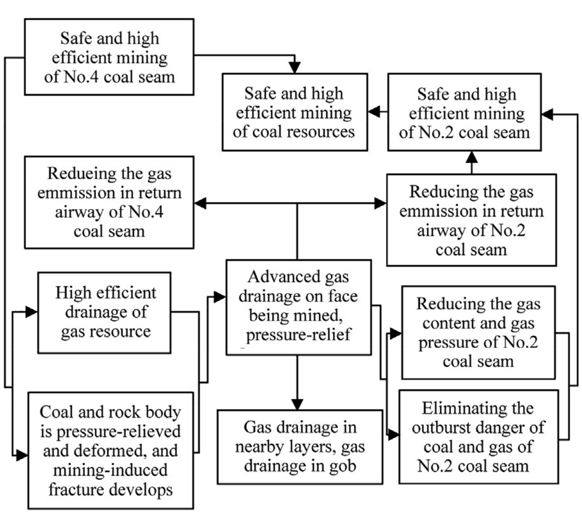


**Fig. 2.** Pressure-relief gas extraction technical model.

## 3. Numerical simulation by FLAC$^{3D}$

### 3.1. Geometric model

According to the geological conditions of No. 2 and No. 4 coal seams, the average spacing between No. 2 coal seam and No. 4 coal seam is 35 m, and the buried depth is approximately 800 m. In order to not influence calculation results, the advancing length of the working face was simplified for the model by taking No. 4 coal seam as the lower protective layer of No. 2 coal seam. The size of the whole model is 210 m (length)×150 m (width) × 100 m (height). The geometry includes 47,880 units and 51 987 nodes. As shown in Fig. 3, the *x*-direction is the incline direction, the *y*-direction is the strike direction and the *z*-direction is the gravity direction of the coal seam.

### 3.2. Boundary conditions and parameters of the numerical model

The boundary conditions around the model are fixed, except for the upper boundary which is not fixed. A compressive stress of 18.716 MPa was imposed on top of the model. The maximal main stress is the vertical stress and the minimal main stress is along the *x*-direction. The minimal main stress is half the magnitude of the maximal main stress. The middle main stress is along the *y*-direction, and it is 60% of the maximal main stress. Mohr-Coulomb failure criterion was used to determine the deformation of the rock body.

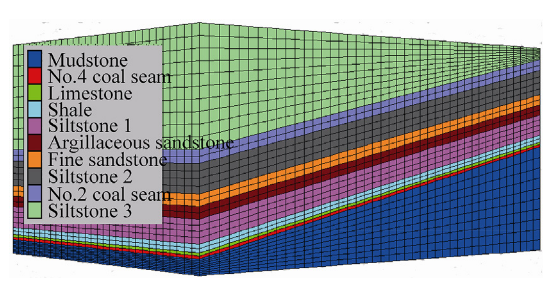


**Fig. 3.** Mesh dissection model.

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