Research on the height of overlying strata "three zones" in deep coal mining

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Abstract. In order to conduct an in-depth study on the height of the three-zone overlying S-type overburden space fissure field in deep mining, the 3322 fully mechanized caving face of a mine was used as the research object, using theoretical calculations, numerical simulations, similar simulation experiments and field measurements. In this paper, the development height of the S-type overburden space fissure field in the deep mining conditions of a mine was studied. The overburden failure range of the overlying strata in deep mining was obtained, and the formulas for the heights of fall zone and fissure zone in the S-type overburden space fracture field of 3322 fully mechanized caving face in a mine were derived, and the 3322 fully mechanized caving was accurately calculated. The calculation results of the surface fall zone and fissure zone are basically consistent with the numerical simulation and similar material simulation results. Based on this theoretical calculation, the height of the overlying strata in the overlying strata in deep mining can be effectively predicted.

1. Introduction
After the coal seam is mined, it will cause the movement and destruction of the height of the three belts of the overlying rock layer. The height of the overlying rock damage is of great significance to the development of coalbed methane and the prevention of gas disasters[1]. Regarding the study of the height of the three belts of the overlying rock layer, the current research methods mainly include empirical theoretical calculation, on-site measurement and numerical simulation calculation[2]. Scholars at home and abroad have done a lot of research on the method of dividing the height of the three zones of the overlying strata[3-5], but there are few studies on the influence range of the height of the three zones of the overlying strata in deep mining. Qian Minggao[6] studied the distribution characteristics of mining fracture zones in the overlying strata, and revealed the distribution characteristics of overlying fractures in the longwall face. Shi Longqing et al.[7] deduced the theoretical calculation formula of water-conducting fracture zone based on the "three zones" division theory of stope roof under the condition of large mining depth. Wang Zhiguo et al.[8] used similar material simulation experiments to analyze the characteristics and distribution of the “three zones” of the overburden strata above the stope.

In this paper, taking the 3322 fully mechanized caving face of a mine as the research object, based on the revised calculation formulas for the heights of the fall zone and fissure zone, the height range of the three belts of the overburden on the 3322 fully mechanized caving face is analyzed, and numerical simulation and similar material simulation experiments are used the method to verify the accuracy of the theory provides important reference data and technical support for the safe mining of a mine.
2. Geological conditions and mining conditions of a mine
A mine has a thickness of 12.21m, a dip angle of 5°-7°, a design strike length of 1385m, a working face length of 150m, and a coal seam burial depth of 858m-1000m. The top coal mining method is adopted.

3. Determining the height of overburden failure in the overburden space fissure field in a deep mining face of a mine

3.1 Simulation analysis of overburden failure height
The spatial fissure field of overlying rock changes dynamically in the horizontal direction, and the maximum height in the vertical direction can be determined by similar simulation, numerical simulation, empirical formula method and field observation. The maximum height of the fracture zone rises stepwise with the advancement of the working face. When the working face is in the square stage, the maximum height of the 3322 working face determined by numerical simulation is 171m; the maximum height of the 3322 fracture zone determined by similar simulation is 168m. As shown in Figure 1, Figure 2.

The definition of the overlying height of the overlying rock fissure field is the range of plastic zone in the numerical simulation during the initial mining. When the working face enters the square stage and communicates with the overlying goaf, the fissure field can reach the previous level directly.

![Fig.1 The maximum height of overburden failure zone determined by numerical simulation](image-url)
3.2 Theoretical analysis of overburden failure height

According to the division formula of mining fracture zones, some scientific research units and mining areas have made some empirical studies. Based on a large number of measured data, they have calculated the maximum height of the fall zone (equivalent to the thickness of the rock layer of the fall zone) and the maximum height of the fracture zone (the empirical formula equivalent to the total thickness of rock strata and fissure zones when the coal seam dip angle is less than 55°)[9-10].

The commonly used calculation heights of fall zone and fissure zone are as follows:

① Maximum height of falling zone $H_1$:
Medium hard cover rock:
$$ H_1 = \frac{100M}{4.7M + 19} \pm 2.2 $$ (1)

② Maximum height of fissure zone $H_2$:
Medium hard cover rock:
$$ H_2 = \frac{100M}{1.6M + 3.6} \pm 5.6 $$ (2)

Using the above-mentioned empirical formula for the water-conducting fissure zone in the prevention and control of water, a 3322 fully mechanized caving face in a mine is calculated to have a fall zone height of 13.7-18.1m and a fracture zone height of 47.0-58.2m. The result calculated by the above formula has a great error with the numerical simulation, similar simulation and the actual drilling data.

In the deep mining of the mine, the vertical stress of the coal seam increases, and the collapse of the overlying rock layer has changed greatly. Therefore, the empirical formula for dividing the fracture zone of the deep fully mechanized caving mining is summarized and analyzed. Meaning, based on the experience of ground drilling in deep fully mechanized caving face of Yima Qianqiu Mine, Kailuan Fangezhuang Mine and other places and the "11th Five-Year Plan" subject "ground drilling The mining technology affects the technology of coal seam gas technology. For the work of mining cracks in the overlying rock layer, the actual borehole data fitting method is adopted according to the specific conditions of a mine, and the above formula is preliminarily revised using matlab software. The combined data are few and cannot represent most of the mines. Only the height of the fall zone and fissure zone of a certain mine is discussed. The fitting diagram is shown in Figures 3a and 3b. The
formula after preliminary correction is:

\[ H_1 = \frac{100M}{0.782M + 26.18} \pm 3.8 \]  

\[ H_2 = \frac{100M}{0.194M + 4.33} \pm 6.9 \]

Figure 3a Matlab fitting diagram of maximum height of falling zone

Figure 3b Matlab fitting diagram of the maximum height of the fissure zone
The maximum heights of the fall zone and fissure zone of the 3322 working face calculated by calculation are 29.9 m ~ 37.5 m, 173.3 m ~ 187.1 m, which are similar to the results of numerical simulation and similar simulation.

4. Conclusion

4.1 The matlab software was used to make preliminary fitting corrections to the commonly used formulas for calculating the height of fall zone and fissure zone, and the formulas for the height of the fall zone and fissure zone for deep mining in a mine were obtained and calculated. The height of a 3322 fully mechanized caving face in a mine is 29.9 m to 37.5 m, and the maximum height of the fissure zone is 173.3 m to 187.1 m.

4.2 Using numerical simulation method and similar material simulation experiment method, the height of the fissure zone of the overlying strata after deep mining of the 3322 fully mechanized caving face of a mine is determined to be 171m and 168m respectively, which verifies the correctness of the theoretical calculation. The theoretical calculation method can effectively predict the overburden height of a mine.

4.3 This paper studies the height of the three belts of the overlying strata in deep mining. Based on the revised theoretical calculations, numerical simulations, and similar material simulation experiments of the overlying strata of the three strata, the heights of the three belts in deep mining are determined, and the field detection experiments verify reliability of research results.

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