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Editorial: Mine engineering geological disaster forecasting, monitoring, and prevention

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Editorial on the Research Topic
Mine engineering geological disaster forecasting, monitoring, and prevention

Due to the gradual depletion of shallow resources and the deepening of resource extraction depth, the engineering geological conditions are more complex. High ground stress, high temperature, high osmotic pressure, strong mining disturbance, and complex geological structure have led to a more frequent occurrence of geological disasters in mines. The common geological disasters mainly include mine water inrush, rock and coal burst (as shown in Figure 1), roof accident, coal and gas protrusion, surface subsidence, fault activation, high steep slope instability, water pollution, and so on. Given the increasing prominence of mine engineering geological hazards and the serious threat to mine safety production, the research on the prediction, monitoring, and prevention of mine geological hazards has become urgent. To this end, Research Topic researched on regional geological characteristics, state of ground stress, nature of surrounding rocks, and support strategies. Furhermore, the disaster-causing mechanism of mine geological hazards, monitoring approaches, and prevention and control techniques were studied and provide an important guarantee for the safe development of mine resources and economic development.

The study of the disaster-causing mechanism of mine geological hazards will help to understand the causes and processes of disaster occurrence in essence and to provide theoretical support for disaster prevention and control. The mechanical property and deformation law of surrounding rock are always the important research content in disaster-causing mechanism of mine geological hazards, and also the focuses of Research Topic. To reveal the causes of dynamic hazards in rock engineering, Wei et al. analyzed the uniaxial damage mechanics and energy evolution law of sandstone using the DIC technique, explored the uncoordinated evolution of the deformation displacement field of rock mass, and revealed the fracture development and failure mode of sandstone specimens under uniaxial compression conditions. Wei et al. investigated the effect of loading rate on the mechanical and fracture properties of shale and found that the peak

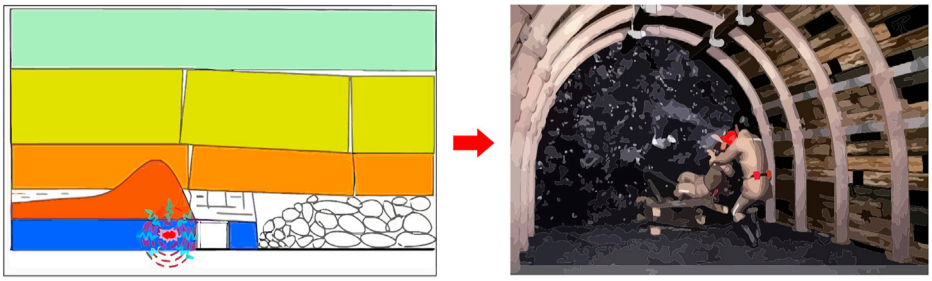

FIGURE 1
Schematic diagram of rock and coal burst disaster.

strength and elastic modulus of shale increased with increasing the loading rate, but there was no significant pattern in Poisson's ratio. Wu et al. researched the mechanism of impact ground pressure in a sub-vertical extra-thick coal seam under the control of a "roof-rock pillar" by numerical simulation and microseismic analysis, which revealed that the superposition of dynamic disturbance caused by roof and pillar failure and high static stress in a coal seam is the cause of rock burst in the B3 + 6 coal seam. In addition, He et al. reviewed the application of micromechanical methods in mechanics of complex rock masses and provided a new approach to analyze the mechanic law of the disaster-causing mechanism. Yi et al. analyzed the characteristics of overburden movement and the law of surface movement in areas with exposed bedrock, which explained the causes of sudden water explosion disasters.

The research on the action mechanism of water on coal/rock/soil is also an important topic of mine geological disaster theory. The influence of water not only leads to the redistribution of chemical elements between coal/rock/soil and water, but also leads to the changes in the microstructure and mechanical properties of coal/rock/soil, then inducing engineering geological disasters. Lu et al. studied the risk of coal and gas outburst under different water content, which provided new insights for the theoretical study of coal and gas outburst and the hydraulic prevention and control measures of coal and gas outburst. Wang et al. used PFC numerical calculation software to study the mechanical properties and fracture propagation characteristics of fractured rock mass under the coupling effect of heavy rainfall infiltration and mining unloading. It was found that the compressive strength and peak strain of the rock decreased as the pore water pressure of the rock increased, and the pore water pressure accelerated the destruction process of the rock. Zhang et al. proposed a saturated-unsaturated seepage random field model to analyze the effects of rainfall intensity, rainfall duration, and spatial variability of the saturated hydraulic coefficient on the infiltration process and stability of unsaturated rocky slopes, which provides reference significance for the risk assessment of rainfall infiltration-induced slope geological hazards. Zhao and Wei conducted a systematic study on the porosity and permeability of coal from two areas of the Dahebian landslide in the Liupanshui coalfield and found that the internal mechanism of permeability loss is related to fracture closure and plastic deformation caused by confining pressure. Cao et al. investigated the effects of key factors (gradient, temperature, and initial dry density) on the soil-water characteristic curves of fine-grained tailings dams, which provided the support for stability assessment and prediction of unsaturated tailings dams. To understand the risk of tailings pond failure, Chen et al. studied the flow characteristics of slurries with different concentrations in tailings dams and conducted a series of flume experiments to obtain the flow characteristics such as inundated height, impact force, and velocity at 30%, 40%, 50%, and 60% concentrations.

The development of disaster monitoring technology has a crucial impact on the prediction and prevention of mine geological disasters. Its main task is to monitor the spatial evolution information and inducing factors of geological disasters, and to obtain continuous spatial deformation data to the maximum extent. The research of disaster monitoring technology can effectively predict and prevent the occurrence of disasters. For example, in the safety monitoring of tailings dams, Nie et al. developed a 3D visual early warning system for tailings dams by combining the GIS (geographic information system), ARIMA (autoregressive comprehensive moving average model) and 3S (RS, GIS, GPS) technologies to predict phreatic line changes and tailings dam deformation. The system solves the problems of low visualization of monitoring data, poor management of various data, and prediction and early warning of the point–surface combination. For the monitoring and warning of surrounding rock stability, Xu et al. proposed an object-oriented method combined with an improved recursive algorithm to realize the visual computation of key strata. Then, the object-oriented application was developed and applied in the Xia Dian coal mine in Shanxi, verifying the practicality and efficiency of the method. For the coal gas outburst disaster, Wang et al. proposed an early warning method for predicting coal and gas emergencies based on the deep learning model and statistical model indicators, which has advantages in predicting emergencies. For the monitoring of sudden water accidents in coal mines, it is crucial to accurately grasp the development height of the water-conducting fractured zone. To this end, Feng et al. used a combination of drilling and 3D seismic exploration to study the 3D development characteristics of the water-conducting fractured zone in the middle and deep coal seam mining. The height and morphology of the water-conducting fractured zone were measured using the first mining face of Xiaobodang No.1 mine as an example.

Disaster prevention and control are the most critical tasks of Research Topic after understanding potential engineering disasters. For example, for the potential roof collapse disaster caused by the empty area or irregular damage zone left by coal mining, Chen et al. proposed a damage zone filling repeated mining method based on the analysis of the disaster state when the working face passes through the existing damage zone, which provides an effective practical reference for preventing roof collapse hazards. In the goaf backfilling, gangue is often used as the main solid backfilling material. Therefore, Wang et al. established the laboratory coal gangue compaction test system and carried out research on the compaction characteristics (such as stress-strain, stress volume density, and stress-deformation modulus) of coal gangue in deep backfilling mining. Through monitoring the surface subsidence, it is found that the backfilling technology with an initial compression force of 2.5 MPa can effectively control the surface subsidence. Yin et al. used alkali slag-modified gangue backfill material to further improve the surface settlement control. Qiu et al. conducted uniaxial compression strength tests and permeability tests to investigate the strength and permeability characteristics of cemented tailings backfill with different cement-sand ratios and different waste rock contents. To control the deformation of mine surrounding rock and ensure its stability, Wu et al. studied the load concentration of the coal pillar and the goaf floor, as well as the stress distribution characteristics of the coal pillar area before and after the top slice, and determined the suitable location of the lower slice roadway in the residual pillar area after top slicing of thick coal seam, which achieved a better effect of surrounding rock management. To better prevent the collapse deformation of the roadway, Han et al. proposed an optimized support scheme by analyzing the deformation damage characteristics of the roadway surrounding rock caused by penetrating hydraulic reaming using ground-penetrating radar technology. To ensure the stability of the gob-side entry when experiencing quick subsidence of the hard roof, Zhang et al. researched roof-cutting pressure relief of the gob-side entry retaining with roadside backfilling, by establishing a roof-cutting mechanical model and using a numerical simulation. In addition, coal and gas protrusion, as an extremely serious dynamic hazard, seriously threatens the safe production of coal mines. Zhang et al. conducted a study on coordinated slag disposal from horizontal boreholes during hydraulic cutting based on two-phase flow theory, which could result in 4. 5 times higher average net gas extraction in coal mines compared with conventional boreholes, 25 times higher gas permeability coefficient, and more than double the effective extraction radius.

Author contributions

The author confirms being the sole contributor of this work and has approved it for publication.

Conflict of interest

The author declares that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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