frontiers | Frontiers in Earth Science

TYPE Editorial
PUBLISHED 28 December 2022
DOI 10.3389/feart.2022.1071841

OPEN ACCESS

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SPECIALTY SECTION
This article was submitted to Geohazards and Georisks, a section of the journal Frontiers in Earth Science

RECEIVED 17 October 2022
ACCEPTED 04 November 2022
PUBLISHED 28 December 2022

CITATION
Wang S, Liu H, Li L and Zhang C (2022), Editorial: Geological disasters and its prevention in deep mining.
Front. Earth Sci. 10:1071841.
doi: 10.3389/feart.2022.1071841

Editorial: Geological disasters and its prevention in deep mining

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KEYWORDS

deep mining, disaster mechanism, soft rock, large deformation, rockburst

Editorial on the Research Topic
Geological disasters and its prevention in deep mining

Introduction

With the gradual depletion of shallow mineral resources, the mining of deep mineral resources has become inevitable. The geological disasters such as large deformations of soft rocks, rock bursts, and gas outbursts induced by the deep mining have brought great challenges and seriously threatened the safety of mine productions. Under the conditions of high ground stresses, high water pressures and strong engineering disturbances, the nonlinear behavior of deep coals and rocks is more prevalent in deep mining, which may further complicate the forming mechanisms, patterns and dynamics of the geological disasters. Thus, deep mining-induced disasters have the characteristics of sudden, complexity and nonlinearity, and are more difficult to effectively forecast and control. Since the traditional mining theory lags behind the mining engineering practice, it is urgent to develop new theories and methods to solve the theoretical and technical challenges of deep mining.

We then provide a forum for professionals and academics to communicate their impactful research on Geological Disaster and Its Prevention in Deep Mining, which results in the 15 papers being published in this Research Topic that might be of your interest. These papers mainly cover the following six aspects, such as experiment on mechanical characteristics of rock samples, rockburst prediction and mine waterproofing, surface deformation and foundation subsidence, gas migration and its enhancement drainage, deformation characteristics of surrounding rock in roadway, and stability and support of mining field. Please visit the following website for more information: https://www.frontiersin.org/research-topics/34613/geological-disasters-and-its-prevention-in-deep-mining#overview.

Experiment on mechanical characteristics of rock samples

Rock reinforcement plays a significant role in maintaining the stability of excavated structures, such as tunnels and underground roadways. However, shear failure in the rock reinforcement system, especially the shear failure at the rock reinforcement bolt surface, induces a threat to the rock reinforcement system. To reveal the shear stress (SS) propagation mechanism, Chen et al. presented the SS propagation process in the rock reinforcement system. They stated that the numerical simulation was a better choice when studying the SS propagation mechanism of rock reinforcement bolts, combining experimental tests and analytical simulation. Engineering problems are related to the failure of geological materials, especially that of jointed rock masses. To investigate the influence of confining stress and inclination angle on cracking behavior and failure mechanism, Sun et al. conducted triaxial compression tests on rock-like samples containing parallel opening flaws. They investigated the influence of the width-to-length ratio of opening flaws on compressive strength to verify the improved theory reliability. Comparing their numerical results with the two kinds of theoretical results, they concluded that the width-to-length ratio had an obvious impact on compressive strength and the opening fracture intensity factor.

Rockburst prediction and mine waterproofing

After the identification of the intrinsic relationship between multiple factors of coal mines and rockbursts, Lan et al. established a prediction model based on the Gaussian process for binary classification. They proposed the prediction criteria of the rockburst hazard probability, determined the hazard probability value of the prediction area by applying neural network and fuzzy inference methods, and put forward the prevention technical scheme for the rockburst hazard. To study the effect of loading rate on rockbursts, Sun et al. conducted the indoor test of single-face fast unloading-three directions and five-face stress-vertical continuous loading under different loading rates using a new true-triaxial rockburst test system. They found that the fragmentation degree of rockburst fragments increased with the loading increasing. The loading rate has a significant effect on the energy consumption of rockburst fragments. It is necessary to introduce concrete 3D printing technology for the construction of coal mine waterproof walls to adapt to more complex construction environment. Ren et al. tested the compressive properties of 3D printed concrete under different printing methods and force directions. They found that 3D printing mine waterproof walls can meet the engineering requirements.

Surface deformation and foundation subsidence

To make a reasonable safety evaluation of the high-speed railway construction in the mined-out areas, Ren et al. analyzed the safety depth of the mined-out areas under the impact of high-speed railway loading. They found that the depth of train load disturbance was linearly related to the train axle weight and roadbed height but it was a sinusoidal function of the train speed. They proposed a formula for calculating the depth of train load disturbance, which provided a certain reference for the construction of high-speed railways in the mined-out areas. Deep mining is an inevitable trend in the world, for which the construction of deep and large vertical shafts is the primary task. The design of the shaft sinking headframe is challenging due to the significant differences in the geometry and working load compared to conventional steel structures. Wang et al. investigated the mechanical behavior of the SA-3 shaft sinking headframe under uneven foundation settlement and normal working-load conditions. They found that the most unfavorable condition for the stress of members was the diagonal double foundation settlement, and the most unfavorable condition was the same-side double foundation settlement.

Gas migration and its enhancement drainage

Hydraulic flushing is the main means of gas extraction. Liu et al. studied the pore morphology and permeability evolution of the hydraulic flushing hole. They found that the shape of the hydraulic punch hole was ellipsoid with three different axes, and its horizontal section was approximately an ellipse. The permeability of the coal increases with the extension of extraction time, while the permeability of the equivalent ellipsoid pore decreases with the increase in coal water content. To enhance permeability by blasting in deep coal mining with a hard roof whose gas drainage requirement is higher, the charging and control holes are easy to be deformed and damaged, seriously affecting the blasting implementation and effect. Xuan et al. proposed a new blasting permeability enhancement scheme for the deep-buried soft coal mining face with a hard roof. To reveal the mechanism of gas flow in a low-permeability coal seam, Liu et al. established a new multiple-relaxation-time lattice Boltzmann method model of gas migration and simulated the gas flow in coal pores with different micro/nanopore sizes. They found that the dimensionless permeability coefficient increased with decreasing pore size under the same pressure.

Deformation characteristics of surrounding rock in roadway

Argillaceous soft rocks are susceptible to a more serious creep phenomenon if encountering water. Chen et al. established a creep constitutive model and analyzed the creep range and cross-sectional deformation of argillaceous surrounding rocks of a roadway under dry and damp states. They found that the argillaceous surrounding rocks were prone to viscoelastic deformation during the creep process. The damp state has an obvious time effect on the damage of surrounding rocks. Since it was difficult to monitor the deformation of a rockmass in front of a tunnel, Zhu et al. conducted the model test and concluded that it was necessary to pre-reinforce the core rockmass in front of the tunnel to control the advanced deformation of the tunnel. The longitudinal load-bearing arch in front of the tunnel face can effectively control the extrusion deformation of the core rockmass to expand forward. The failure of surrounding rock in deep hard rock roadway is closely related to mining disturbance. Li et al. proposed a comprehensive method of numerical analysis and borehole detection, and they revealed the evolution law of fracture depth of the surrounding rock under the mining influence.

Stability analysis and control of mining field

Given the growing popularity of fully mechanized longwall mining, hydraulic shields have emerged as the most crucial pieces of equipment whose rated support capacities are a significant assurance for safe extraction of coal seams. Ren et al. studied the reasonable shield support capacity under an extremely close goaf. They found that the thickness of the main roof had the greatest influence on the shield support capacity. Presplitting the main roof is proposed as an effective method for controlling the breaking length and reducing the shield support capacity based on existing research. In view of the deformation and instability law of hard roof without side filling retaining roadway and based on the systematic construction and analysis of the force and bearing model of roadway retaining structure, Long et al. proposed the control mechanical model and calculation method of roadway retaining, which took the anchor roof beam and the key block above to form the cantilever beam together, with the anchor solid coal side as the foundation support. This method can better improve the structure for stability, adaptability and engineering applicability, which is successfully applied in engineering practice.

We hope that these articles provide readers with valuable information on recent developments in science, technology, and related researches for achieving the goals of geological disaster prediction and prevention in deep mining.

Author contributions

All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

Conflict of interest

The authors declare 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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