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Editorial: Geological disasters in deep engineering: mechanism, warning and risk mitigation

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Editorial on the Research Topic
Geological disasters in deep engineering: mechanism, warning and risk mitigation

Introduction

With the increasing demand for infrastructure construction as the global economy progresses, the need for exploration and utilization of deep underground space becomes more crucial. Various deep underground projects are planned, are under construction, and have been built to encounter great construction challenges due to the complex geo-environment such as strong tectonic movement, fragile geo-environment and complex thermo-hydro-mechanical-chemical conditions. These deep engineering projects could be endangered by different kinds of geological disasters, such as intense rockburst, large deformation, strong water inrush, and large-scale collapse, which might result in massive loss of life and economic damage during the construction of deep underground projects.

Efforts are being called for strengthening science and technology innovation and cooperation in geological disaster mitigation and sustainable development during the construction of deep engineering projects. To mitigate the risk of geological disaster in deep engineering under the complicate geo-environment, the mechanism of the formation and evolution of geological disasters in deep engineering needs to be understood. The testing, monitoring, simulation, risk assessment and early warning methods for geological disaster in deep engineering are also needed urgently. New theories, methods and techniques related to the mechanism, warning and risk mitigation of geological disasters in deep engineering will be extremely helpful for the construction safety of deep engineering.

Progress in the Research Topic

In order to attract scholars' attention to geological disasters in deep engineering, the current Research Topic "Geological disasters in deep engineering: mechanism, warning and risk mitigation" was organized. This Research Topic has an overarching focus on new theories, methods and techniques that have been developed to reveal the mechanism and to warn and mitigate the risk of geological disasters in deep engineering. There are 38 papers in this Research Topic with 210 authors. According to the main content of these papers and the Research Topic, I summarized and divided the papers into three parts and 10 papers were selected to show as an example.

Formation and evolution of geological disasters in deep engineering and their mechanism

Recognition of the characteristics, laws, and mechanisms of geological disasters in deep engineering is the basis for reasonable evaluation, warning, and control of them. Yuan et al. studied the influence of the Xianshuihe fault zone on *in-situ* stress field of a deep tunnel under construction in southwestern China and its engineering effect. Zhang et al. investigated the spatial and temporal distribution of mining-induced seismicity before and after multiple deep-hole blasting and simulated the stress and displacement in hard rock based on the engineering background of a panel of Dongtan deep coal mine. Zhang et al. studied the triggering and relationship between mine earthquake activities and stress of Earth tides during deep mining based on the Yanbei coal mine in China. Wang et al. elucidated the mechanism underpinning the surface deformation of the hanging wall in the eastern part of the Jinshandian iron mine based on surface deformation data collected over a period of 13 years. Zheng et al. studied the failure difference of hard rock based on a comparison between the conventional triaxial test and true triaxial test.

Testing and monitoring technologies for geological disaster in deep engineering

In order to study and reveal the formation mechanism of geological hazards in deep engineering and provide a warning, a series of monitoring and analysis techniques have been developed and optimized, such as microseismic monitoring technology, stress measurement technology, et al. Li et al. studied the influence of the microseismic sensor coordinate error on the microseismic source location and a calculation method for the microseismic sensor coordinate error threshold was proposed and used in Beiminghe iron mine in Hebei Province in China. Zhang et al. proposed an effective denoising method based on cumulative distribution function thresholding and applied it in a metal mine. Wang et al. proposed a deep borehole *in-situ* stress measurement method based on multi-array ultrasonic scanning technology based on the wall collapse in deep borehole.

Risk assessment and warning methods for geological disaster in deep engineering

Risk assessment and warning methods for geological hazards in deep engineering are the basis for specifying prevention strategies and adopting reasonable prevention measures, as well as the prerequisite for avoiding risks and ensuring the smooth implementation of deep engineering. Guo et al. proposed a method that takes into account the *in-situ* stress, rock mass integrity, span length, and depth of highly damaged zone to determine the excavation damage zone in underground engineering. Wei et al. developed a hybrid model based on information entropy and unascertained measurement incorporating four membership functions to evaluate the tunnel squeezing, which is able to enrich the available risk evaluation methods for deep underground excavation projects.

Development trend

Research on evolution mechanism, warning, and risk mitigation of disasters in deep engineering in different fields, such as water conservancy and hydropower, transportation, national defense, and deep basic physics laboratories, is a major topic in engineering construction and operation. The failure characteristics of rockmass in deep engineering are significantly different from those in shallow engineering, posing a huge challenge to the research on rock mechanical properties and disaster mechanism recognition, warning and analysis theory, and risk mitigation. There are various types of disasters in deep engineering, such as rockburst, deformation, water intrusion, collapse, et al. A rockburst is defined as damage to an excavation that occurs in a sudden or violent manner and is associated with a seismic event. The author of this Editorial is mainly engaged in research on the mechanism, monitoring, warning, and control of rockburst in deep engineering. Here, several suggestions on rockburst for future research are given as an example.

Considerable progress has been made in the study of rockburst development process. It includes the characteristics, types, induced effects of construction methods, mechanisms, testing and observation monitoring methods, as well as the theory and technology of rockburst warning and risk mitigation.

Observation, monitoring and mechanism of rockburst in deep engineering

Currently, a systematic indoor and on-site comprehensive observation and monitoring technology for rockburst in deep engineering has been established. The mechanism of rockburst development in deep engineering was revealed to a certain extent. A deeper understanding of the mechanism of immediate rockburst was obtained. However, the monitoring technology and mechanism of time-delay rockburst and intermittent rockburst in deep engineering still need further research.

Warning of rockburst in deep engineering

The author of this Editorial has conducted a large amount of research on the warning of immediate rockburst in deep engineering and proposed a real-time quantitative warning method for rockburst in deep tunnel. Rockburst warning has been changed from qualitative to quantitative through the method. The method has been tested and applied in a large number of deep engineering projects. However, there is still a lack of effective warning methods for time-delay, intermittent, and fault slip rockbursts.

Risk mitigation of rockburst in deep engineering

The prevention and control of rockburst in deep engineering has changed from passive to active. And for intense and extremely intense rockbursts, the prevention and control method has risen from empirical to a scientific method. The future direction of efforts is to research new and efficient stress release technologies, energy absorption support systems, and more engineering practices.

Rockburst case database and artificial intelligence

The development process of rockbursts in deep engineering is a complex process. A large rockburst case database has been established. Using artificial intelligence methods, such as big data and deep learning, to conduct deep learning on rockburst databases and establish a fully intelligent system is a direction that needs urgent efforts. The rockburst mechanism and risk in different deep engineering projects are different with each other. Taking specific engineering examples to conduct rockburst research and enrich the mechanism understanding, warning, and risk mitigation technologies of rockburst in deep engineering are also the future development directions.

Author contributions

The idea of and concept of this Research Topic came from discussion amongst the guest editors. G-LF organized and wrote the manuscript. The author contributed to the submitted version of the article.

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Conflict of interest

The author 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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