

Mining Safety and Sustainability—An Overview

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1. Introduction

The mining industry provides energy and raw material for global economic development and social progress. Especially in recent years, with the increasing improvement in infrastructure facilities and people's living standards, the demand for mineral resources has shown gradual growth; however, the ensuing issues of mining safety and sustainable development are causing increasingly widespread concern and worries. For a more long-term development, a large amount of scientific research has been invested on these issues in the context of long-term development. By making full use of model building [1–4], experimental studies [5–8], field practice [9–12], theoretical innovation [13–16], data analysis [17–19], and technology development [20–23], the possibilities of safety and sustainability in the development of mineral resources have been explored. Useful knowledge is also obtained by reviewing existing studies and integrating resources [24–27], aiming to identify the future direction of the mining industry. This Special Issue aims to focus on the most recent theoretical, experimental, and technological advances in mining safety and sustainability. A brief summary of the articles published in this Special Issue and related recent works are presented in this editorial.

2. Guarantee for Mining Production Safety

Tailings dam failure is a great threat to life and property, and the diagnosis of the health of tailings dams is a complex nonlinear problem. Dong et al. [28] proposed a comprehensive, quantitative method for the diagnosis of tailings dam health based on dynamic weights and constructed a diagnosis index system for tailings dams with slope stability, deformation stability and, seepage stability as project layers. The proposed method was successfully applied to an actual engineering project. This study provides a new method for evaluating the safety of tailings dams.

Ma et al. [29] conducted a model experimental study of the surface settlement characteristics caused by coal seam mining using a special three-dimensional experimental setup. The surface settlement characteristics during mining were also studied in combination with field measurements. The results showed that the subsidence caused by mining disturbances below the coal seam was 79. These findings fully reflect that the three-dimensional test device provides a new experimental research tool that can be used to further study the surface subsidence characteristics and control caused by coal mining.

Combined with the movement principle of rock and soil layers in the respective study area and considering the influence of slope stability and additional mining slip on mining subsidence, Zhao et al. [30] proposed a probabilistic integral model-based surface subsidence prediction method for coal seam mining in loess donga and verified its feasibility by field cases. A new, effective, and valuable tool is provided for the prediction of damage caused by underground coal seam mining.



Citation: Dong, L.; Zhao, Y.; Chen, W. Mining Safety and Sustainability—An Overview. *Sustainability* **2022**, *14*, 6570. <https://doi.org/10.3390/su14116570>

Received: 13 May 2022

Accepted: 23 May 2022

Published: 27 May 2022

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Considering the difficulty of effectively identifying signals with low signal-to-noise ratios (SNRs) using microseismic monitoring, Fan et al. [31] proposed a wavelet scattering decomposition (WSD) transform and a support vector machine (SVM) algorithm. The artificial intelligence recognition model developed based on SVM and WSD not only provides a fast method with high classification accuracy, but is also suitable for online feature extraction of microseismic monitoring signals to achieve improved efficiency and accuracy of microseismic signal processing used to monitor rock instability and seismicity.

To better understand the mining characteristics during mining of shallow buried thick coal seams (SBTCS) under thick aeolian sand (TAS), Liu et al. [32] explored the ground damage characteristics and fracture development during mining under special geological conditions of TAS through theoretical derivation, numerical simulation, and field monitoring. The results revealed the essence of the development and the distribution of surface cracks caused by mining SBTCS, and depth-to-thickness ratio (DTR) was shown to be 13.43.

Considering that chemical corrosion and axial compression affect rocks' internal microstructure and mineral composition, which in turn affects their physical and mechanical properties, Xue et al. [33] used a combined dynamic and static load test apparatus to conduct cyclic impact tests on white sandstone immersed in chemical solution and studied the dynamic strength characteristics of white sandstone under the coupling effect of axial load and chemical corrosion. The results of the study provide a theoretical basis for safe and effective construction management of blasting projects under complex geological conditions.

To study the fracture patterns during rock fracture, Li et al. [34] investigated the acoustic emission characteristics and crack types of red sandstone during fracture by Brazilian indirect tensile tests (BITT), direct shear tests (DST), and uniaxial compression tests (UCT). They also discussed a relatively objective dividing line for tensile and shear crack classification and applied the dividing line to the analysis of the fracture source evolution and the damage precursor. The results of the study will provide a theoretical basis for rock stability judgment and prediction during mining.

Liu et al. [35] conducted a series of conventional triaxial unloading tests to analyze the mechanical properties, strain energy evolution characteristics, and failure modes of saturated rock masses, and their findings are of great significance for strength calculation, safety assessment, and disaster prevention and control.

3. Achievement of Sustainable Development

Considering the serious ecological pollution problems caused by acid mine drainage (AMD), Wu et al. [36] investigated the phytoremediation techniques and mechanisms of AMD through hydroponic experiments with six wetland plants. The results showed that the dominant plants for treating AMD were *Juncus effusus*, *Iris wilsonii*, and *Phragmites australis*; some of the pollutants in AMD were absorbed by plants and rest were removed by hydrolysis and sedimentation processes. These findings provide a theoretical reference for phytoremediation techniques for AMD.

Reinforced TSFs are beneficial for saving land resources, reducing environmental damage caused by mineral extraction, and achieving sustainable production in the mineral extraction process. Ding et al. [37] investigated the effects of freeze–thaw cycles on the mechanical properties and microstructural changes of cementitious material-reinforced tailings by performing unconfined compressive strength (UCS) tests, scanning electron microscope imagery, X-ray diffraction tests, and thermogravimetric tests. The results demonstrated that freeze–thaw cycles eventually reduce the UCS of all tested samples, and the higher the number of freeze–thaw cycles, the greater the damage to the surface morphology and matrix of the tailings.

Wang et al. [38] worked on the integrated management of coalbed methane and hydrogen sulfide at the working face in the coal seam distribution of abandoned oil wells in coal-mine resource areas. The study was conducted through parameter testing, gas composition analysis, source distribution site investigation, and determination of the

influence range of gas and hydrogen sulfide in the coal seam within the influence area of the abandoned wells. The results of this work provide a theoretical basis for further understanding of gas- and hydrogen-sulfide-enrichment patterns at the mining face and the design of treatment measures within the influence of abandoned oil wells.

To address the low productivity, inconsistent management, administrative organization, high raw material waste, and negative social and environmental impacts faced by the Mexican marble industry, Alarcón-Ruiz et al. [39] systematically reviewed strategies and solutions used to address these problems between 2014 and 2021. They collected these surveys as well as industry experiences to propose a triple-helix intervention approach. The results of the study provide guidance for the sustainable development of the marble industry.

4. Optimization Design of Technology and Equipment

Yi et al. [40] investigated the effects of time, track shoe number, and grounding pressure, as well as other influencing factors, on the traction force of deep-sea crawler miner through a direct shear-creep experiment and the direct shear rheological constitutive model. They proved its effectiveness through the traction force experiment of a single-track shoe. The research results provide a scientific basis for the design and optimization of the deep-sea tracked miner.

Under the background that the cemented paste backfill (CPB) technology has been applied to solve the problems of stope instability and surface subsidence for so many years, Chen et al. [41] worked on the factors affecting the strength of CPB. They considered the coupled effects of curing conditions, which have received little attention, and used uniaxial compressive strength (UCS) as an important evaluation index of CPB. They successively performed mathematical modeling and laboratory verification of concrete strength. The findings suggest that the relationship between the UCS of CPB and curing stress develops the function of quadratic polynomial to develop with one variable, while the UCS of the CPB indicates a power function as the curing temperature increases. The conclusions obtained in this study have important implications for the safe design of CPB.

Rivera-Lavado et al. [42] proposed the use of RF split-ring resonators (SRRs) as down-hole passive sensors for real-time crude oil monitoring through the estimation of the dielectric constant. The use of a low-cost SRR passive sensor for the real-time permittivity characterization of hydrocarbon fluids will contribute to solving the problem of performing difficult monitoring under harsh conditions such as high temperature and pressure.

5. Trends in Intelligent Mines

Considering the influence of the process parameters of fully mechanized caving on the recovery rate and gangue content of top coal, Liang et al. [43] used numerical simulation and a BP neural network to achieve the optimization of top-coal caving parameters for the actual situation of a working face. They demonstrated the effectiveness of this method using an in-lab similarity simulation test of the particle material. The findings of this paper effectively improve the decision-making efficiency of fully mechanized caving-process parameters and provide a basis for achieving intelligent, fully mechanized cave mining.

To solve the airflow reconstruction problem, Liu et al. [44] proposed a new algorithm of an independent cut set depending on the underlying graph structure and evaluated its effectiveness in practical applications. The results indicated that fewer than 30% of tunnels needed to have wind speed sensors set up to reconstruct the well-posed airflow of all the tunnels (>200 in some mines). The findings of this work provide some theoretical support for the implementation of intelligent ventilation.

Wang et al. [45] combined artificial intelligence techniques to analyze and model experimental data from circulating pipelines, using random forest machine learning algorithms to predict the pressure loss of slurry transport. The results of the study showed an accuracy of 0.9747, which met the design accuracy requirement. This finding will help to realize the optimal arrangement of deep-well-filling slurry-delivery pipelines.

To remedy the deficiencies of the previous studies, Wu et al. [46] proposed a neural network model consisting of one deep neural network (DNN) and four long short-term memory (LSTM) networks based on single-sensor and multi-sensor prediction results. They solved the amplitude-concentrated, expanded region-identification problem. The high-precision model for the automatic identification of amplitude-concentration-expansion zone provides the basis for the automatic identification of borehole depth.

In order to explore the explosion mechanism of coal and the factors that cause coal explosions, Khan et al. [47] used explosivity tests at different particle sizes and dust concentrations to construct a random forest algorithm, which was used to model the relationship between inputs (coal dust particle size, coal concentration, and gross calorific value (GCV)). To further understand the impact of each feature causing explosibility, the random forest AI model was further analyzed for sensitivity analysis using SHAP (Shapley Additive exPlanations). This work provides a reference for control factors to prevent coal dust explosions and improve safety conditions.

We sincerely thank all the above-mentioned authors for the excellent and meaningful contributions to this topic. Additionally, we hope that more relevant research will be conducted in the future to handle the issues about safety and sustainability in the mining industry. It will be helpful for providing further theoretical support and technical support in order to guide the normative, green, safe, and sustainable development of the mining industry.

Funding: This research received no external funding.

Conflicts of Interest: The authors declare no conflict of interest.

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