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Editorial

Computational and Experimental Investigations of Fluid Flow in Rock Materials

Dan Ma,[1] **Zhongwei Chen**,[2] **Yan Peng**,[3] **and Mohsen S. Masoudian**[2]

[1]*School of Resources and Safety Engineering, Central South University, Changsha, Hunan 410083, China*
[2]*School of Mechanical and Mining Engineering, The University of Queensland, St. Lucia, QLD 4072, Australia*
[3]*School of Petroleum Engineering, China University of Petroleum (Beijing), Beijing 102249, China*

Correspondence should be addressed to Dan Ma; dan.ma@csu.edu.cn

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Fluid flow in rock materials can be extremely complex largely because of the concurrent effect from multiphysical processes, e.g., geomechanical deformation, hydraulic flow, chemical reaction, and thermal expansion/shrinkage. Understanding of fluid flow behaviors is of great significance to many engineering fields, such as mining engineering, civil engineering, geothermal engineering, waste and CO_2 geological sequestration, and petroleum engineering [1–4]. This special issue aims to address the critical technical issues and grand challenges related to the aforementioned field. Rock is a kind of heterogeneous material containing natural fractures due to geological deposition and folding. The fracture network created by the expansion of induced fracture and its intersection with natural fracture is complex [5]. Thus, it is of vital importance to understand the mechanism of fluid flow in rock materials.

Water and gas are the two most common fluids in rock engineering, causing the safety concerns to many rock engineering, e.g., water inrush and gas outburst in mining, and instability in slope engineering [6, 7]. Recently, a large quantity of studies focused on fluid flow in rock materials, containing theoretical analyses, laboratory experiments, and numerical simulations [8–11].

Gas outburst is probably the most critical threat to underground coal mining, often causing devastating consequences. Gas drainage using boreholes is a common practice, and significant processes have been present in the past few decades. C. Fan et al. numerically investigated rational boreholes arrangement of gas extraction from the unloaded coal seam. The research results show that the permeability of protected coal seams can be characterized by different zones, where the gas pressure decreases most slowly in the permeability-reduced zone.

Rock burst is an important issue for deep underground excavations. T. Lan et al. investigated the relationships between the principal stresses and the concentration coefficients (i.e., k_1, k_2, and k_3) of the gravity stress to reveal the mechanism of rock burst. The result shows that the trend of released energy of damaged coal has good consistency with the variation of permeability, and water injection can reduce the stress concentration and energy concentration of the rock burst system.

Hydraulic fracturing, as an effective stimulation method, is widely used in enhancing unconventional gas production, such as shale gas, tight sandstone gas, and coal bed methane. Recently, lots of researchers investigate the impact of fracturing fluids on the propagation of hydraulic fractures. Y. Gao et al. conducted fracturing experiments and numerical simulations on the red sandstone by using water and nitrogen gas. The results indicate that the breakdown pressure of nitrogen gas fracturing is 60% that of the water fracturing. The nitrogen gas fracturing also causes greater volumetric strain and a more complex fracture pattern in terms of the number, length, and width of the cracks. Y. Hao et al. established an elastoplastic softening damage model for soft coal seams during hydraulic fracturing, which takes into consideration the lower elastic modulus and tensile strength and higher pore compressibility and plastic deformation. The results indicate that the fracture-influenced radius increases rapidly with an increased injection rate initially.

After reaching the maximum value, fracture-influenced radius decreases slowly with the further increase of the injection rate. Finally, it remains constant. The fracture-influenced radius rapidly increases initially at a certain time and then slowly increases with the injection time.

In mining excavation, it is of significant importance to understand the mechanism of roof fall in the roadway and to focus on the roadway support. And the study of rock strata and hard roof is an effective way to understand supporting control. W.-l. Shen et al. used an experimental method with plane-stress conditions to simulate the mechanical behavior of the rock strata during mining based on a 2D physical model. The results show that the hard roof undergoes bending down, fracture, and caving activation successively until it is able to support overlying loads. The abutment stress which is induced from the loading transfer in the stiff coal pillar is larger than that in other rocks around the retained entry in amplification, and overlying loads above the worked-out area have a loading effect on the unworked-out area. When the hard roof is situated in the activation state, the dynamic stress is generated from the hard roof activation, which is verified by the great saltation of acoustic emission signals. S. Gu et al. investigated the occurrence mechanism of roof-fall accidents and proposed a new supporting design, including a more reasonable arrangement of anchor cables and bolts, bolts with full-length anchorage which are applicable in the cracked and water-rich roadway, high-strength anchor cables, and criss-crossed steel bands.

Water inrush is a constant concern for tunneling and underground mining operations. Water inrush occurs when fractures (i)propagate and interconnect with each other, (ii) form a very conductive fracture network, and (iii) connect with the pressure-bearing water source. B. Zhang and Z. Lin proposed an all-purpose computing method for quicksand disaster through a borehole based on the method of fluid mechanics. To apply and popularize this method, the impact laws of water yield properties of an aquifer on the volume flux were discussed. The all-purpose computing method can be suitably used for the volume flux calculation of quicksand disaster through the borehole.

Z. Zhu et al. provided an effective solution for improving oil recovery in brown fields by combining the rigorous mathematical nature of finite volume simulation and the power of streamline-based flood management. H. Li studied the seepage properties and pore structure of the roof and floor strata in confined water-rich coal seams. The results indicate that the fissure confined water in coal seams has a strong relationship with total stress-strain permeability and development characteristics of the pore structure of the roof and floor strata.

H. Kong and L. Wang used seepage instability theory to study the water-inrush mechanism in the fractured geological structure using a new experimental system, revealing the distribution of the permeate times and lost mass of different Talbol power exponents. The time-varying rules of water pressure, water flow, lost mass, and porosity are also revealed through the results.

X. Shi et al. conducted the nonlinear seepage test on the fractured sandstones of the coal seam roof to investigate the influence of seepage pressure, porosity, and fractal dimension with a self-developed experimental system.

C. Jiang et al. proposed an analytical solution for the seepage field in the water-filled karst tunnel based on the inversion of complex function and groundwater hydraulics theory, which considers the distance between the tunnel and the cavern, the size of the cavern, and the properties of the lining structure. The results show that when the radius of the cavern is constant, the pressure head and seepage flow decrease as the distance between the tunnel and the cavern increases. When the distance is constant, the pressure head and seepage flow increase with the increase of the radius of the cavern. As the thickness of the initial support increases, the pressure head gradually increases and the percolation decreases.

Significant permeability variation of the granular rocks under the effect of hydraulic pressure with compacted regions and the formation of pathways has been reported.

C. Li et al. used an EDEM-FLUENT coupling simulation system to implement a numerical simulation studying variable-mass permeation of broken rock mass under different cementation conditions, and time-dependent change laws of parameters like porosity and permeability and the mass loss rate of broken rock specimens under the erosion effect were obtained. The results show that the permeability change in broken rock specimens under the particle migration effect can be divided into different phases. Specimen fillings continuously migrate and run off under the water erosion effect, and porosity and permeability rapidly increase and then tend to be stable. Cementation degree has an important effect on permeability of broken rock mass.

R. Gui et al. used the sand columns inoculated with the indigenous microorganism to investigate the effect of bioclogging during the radioactive effluent percolation. The hydraulic gradient, volumetric flow rate, and uranyl ions concentration were monitored over time. The results indicate that the propagation of *Aspergillus niger* can clog the seepage channel and effectively adsorb the uranyl ions of radioactive effluent in the porous media, which provides a suitable measure for controlling the migration of radioactive effluent of the uranium tailings reservoir into the subsurface environment.

Y. Jin et al. studied the effects of the grain-sized mixtures (distribution) and the stress state on the mechanical behaviors of grouted crushed coal specimens with a self-designed grouting apparatus, finding that the average slope values of the σ_p-σ_3 curves for the grouted specimens with different grain-sized mixtures were all larger than those of the σ_r-σ_3 curves. Moreover, it was also found that the reinforcement effect of the grouted specimen related to the splitting grouting mode (occurring in most of the large specimens) seems to be better than that related to the penetrating (filling) grouting mode (in most of the small specimens).

The studies included in the special issue represent promising processes in the field in terms of both theories and their direct applications. However, there are still many critical issues and challenges that need to be further improved. Some of them are listed as follows:

(1) The current drainage practices do not appear to have effectively addressed these challenges as evidenced by continuing occurrence of gas outburst incidents worldwide. Better understanding and new practices are still needed.

(2) Despite the inrush mechanisms being reasonably clear, techniques or methods to quantify water inrush and to accurately predict the time of inrush occurrence do not appear to be available.

(3) The deformation of rock materials associated with fluid extraction is often time dependent. The effect of creep and damage on weak rocks has not been well studied in the literature.

Overall, this special issue only addresses some of the critical issues related to energy and resources sectors. We hope that these studies are helpful to achieve better understanding of this complex, to design more effective well patterns, and to improve operation safety and efficiency.

Conflicts of Interest

The editors declare that they have no conflicts of interest regarding the publication of this special issue.

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Dan Ma
Zhongwei Chen
Yan Peng
Mohsen S. Masoudian

References

[1] D. Ma, H. Duan, X. Cai, Z. Li, Q. Li, and Q. Zhang, "A global optimization-based method for the prediction of water inrush hazard from mining floor," *Water*, vol. 10, no. 11, p. 1618, 2018.

[2] E. Hoek and J. D. Bray, *Rock Slope Engineering*, CRC Press, Boca Raton, FL, USA, 2014.

[3] G. Galli, A. Grimaldi, and A. Leonardi, "Three-dimensional modelling of tunnel excavation and lining," *Computers and Geotechnics*, vol. 31, no. 3, pp. 171–183, 2004.

[4] Q. Zhang, D. Ma, Y. Wu, and F. Meng, "Coupled thermal–gas–mechanical (TGM) model of tight sandstone gas wells," *Journal of Geophysics and Engineering*, vol. 15, no. 4, pp. 1743–1752, 2018.

[5] L. Ren, Y. Su, S. Zhan, Y. Hao, F. Meng, and G. Sheng, "Modeling and simulation of complex fracture network propagation with SRV fracturing in unconventional shale reservoirs," *Journal of Natural Gas Science and Engineering*, vol. 28, pp. 132–141, 2016.

[6] D. Ma, X. Cai, Z. L. Zhou, and X. B. Li, "Experimental investigation on hydraulic properties of granular sandstone and mudstone mixtures," *Geofluids*, vol. 2018, article 9216578, 13 pages, 2018.

[7] D. Ma, X. Cai, Q. Li, and H. Duan, "In-situ and numerical investigation of groundwater inrush hazard from grouted karst collapse pillar in longwall mining," *Water*, vol. 10, no. 9, p. 1187, 2018.

[8] K. Wu and J. E. Olson, "Simultaneous multifracture treatments: fully coupled fluid flow and fracture mechanics for horizontal wells," *SPE Journal*, vol. 20, no. 2, pp. 337–346, 2015.

[9] Q. Zhang, D. Ma, J. F. Liu, K. Zhang, and Z. Q. Fan, "Numerical studies on the failure process of heterogeneity rock material with pre-existing fracture under uniaxial compression," *Advances in Civil Engineering*, vol. 2018, Article ID 9203549, 12 pages, 2018.

[10] P. Emge, J. Moeller, H. Jang et al., "Resilience of bacterial quorum sensing against fluid flow," *Scientific Reports*, vol. 6, article 33115, 2016.

[11] D. Ma, M. Rezania, H.-S. Yu, and H.-B. Bai, "Variations of hydraulic properties of granular sandstones during water inrush: effect of small particle migration," *Engineering Geology*, vol. 217, pp. 61–70, 2017.