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Editorial

Challenges in the Mining and Utilization of Deep Mineral Resources

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As Mote et al. [1] have noted in this journal, advances in the fields of engineering science and technology have played an indispensable role in shaping the social and economic development of humankind. However, the continuing development of science and technology, along with the world's ever-growing population, is consuming the earth's resources, including its mineral resources, at what may ultimately prove to be unsustainable rates. After hundreds of years of mining, the more accessible shallow mineral resources are being depleted, and some have now been completely exhausted. This means that the economic exploitation of more of the earth's deeper mineral resources is now required in order to meet society's growing demand for minerals. This demand is not only for the traditional metallic ores and energy sources, but also for minerals such as rare earths, which are being used at an increasing rate with the advent of new technologies in the fields of communication, power generation, and power storage, among others. The efficient mining and utilization of deep mineral resources is not one of the Grand Challenges for Engineering that were identified in recent years by the US National Academy of Engineering, the UK Royal Academy of Engineering, and the Chinese Academy of Engineering (CAE), as listed by Mote et al. [1]. However, it is clear that traditional and newer mineral resources will be required in order to develop solutions to most of the Grand Challenges that have been identified.

Exploitable mineral resources exist at great depth in the form of a number of orebody types in a range of geological and geometrical settings. The current seven deepest mines in the world mine tabular or stratiform gold deposits in the Witwatersrand Basin of South Africa. The deepest of these mines are now around 4 km deep. The next deepest mines in the world are two base metal mines in Canada, which are about 3 km deep. For the purpose of this discussion, deep mining is taken to involve mining at depths of more than 1 km. The effective development and extraction of deep mineral resources face a number of engineering challenges arising from factors such as high *in situ* and induced stresses, and the responses of variable rock masses to these stresses; high *in situ* temperatures, and the associated ventilation and cooling requirements; the difficulty and cost of exploring deep, and sometimes blind, deposits; the complex and difficult mining conditions that are often encountered; safety concerns leading to the desirability of developing non-entry methods of mining; and methods and costs of handling mined ore at depth and transporting it to the surface. In some extreme cases, new, low-cost, and non-traditional methods of extraction will be required.

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Against this background, deep mining has been identified as an important topic for research under China's State Key Research and Development Program, with several State Key Laboratories having been established under that program. This special issue of the CAE's journal, *Engineering*, focuses on Efficient Exploitation of Deep Mineral Resources; it follows on from a China Engineering Science and Technology Forum on the same topic that was held in Beijing in October 2016, and was sponsored by the CAE. The proceedings of that forum will be published by Higher Education Press, Beijing, in September 2017 [2].

The Guest Editors are grateful to the CAE for this opportunity to assemble this special issue of *Engineering*; we also offer our thanks to those who have provided contributions and to those who have taken part in the associated review and editorial processes. This special issue contains the following five papers by selected international and Chinese authors:

(1) "Some challenges of deep mining," by Charles Fairhurst: This stimulating paper by one of the world's most distinguished mining engineers is written from the perspective of a reader who does not necessarily have a background in mining or rock engineering, and thus provides a valuable introduction to this special issue.

(2) "Monitoring, warning, and control of rockburst in deep metal mines," by Xia-Ting Feng and colleagues: As noted by Professor Fairhurst, the understanding and alleviation of rockbursts have long provided one of the major safety and rock engineering challenges for deep mining. This paper reports on some recent advances made in

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monitoring and controlling rockbursts in deep metalliferous mines.

(3) "Opportunities and challenges in deep mining: A brief review," by Pathegama G. Ranjith and colleagues: This paper discusses a number of novel or non-traditional and high-technology approaches to deep mining, with an emphasis on non-entry extraction methods.

(4) "The use of data mining techniques in rockburst risk assessment," by Luis Ribeiro e Sousa, a distinguished Portuguese engineer, and colleagues: Like the second paper listed above, this paper addresses the important problem of rockbursts in deep mining; however, it does so using a range of modern data mining techniques, including Bayesian network classifiers.

(5) "Key technology research on the efficient exploitation and comprehensive utilization of resources in the deep Jinchuan nickel deposit," by Zhiqiang Yang: Finally, this paper reports on the approaches that have been successfully used to improve the exploitation and utilization of a major Chinese base metal resource now being mined at more than 1 km below the surface.

References

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