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Editorial

Editorial for Special Issue "3D/4D Geological Modeling for Mineral Exploration"

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With the development of high-precision geological observation technology, in situ mineral microanalysis technology, isotope geochemical analysis technology, deep geophysical exploration technology, deep drilling, real-time mining, remote sensing high-resolution hyperspectral image technology, and supercomputer and industrial intelligence, geoscience has entered an era of big data and artificial intelligence in the 21st century. Three-dimensional/four-dimensional (3D/4D) geoscience modeling with the multi-disciplinary intersection of geosciences has been used as the basis for mineral exploration and the extraction of geosciences information for mineral resources assessment. The European Geosciences Union launched the second phase of the OneGeology plan using 3D/4D modeling, artificial intelligence technology, and a big data methodology at the Resources for Future Generations conference (RFG2018) [1].

Three-dimensional/four-dimensional geological modeling is a key technology and methodology for geologists to understand geological events and quantitatively analyze multiscale metallogenic models for mineral exploration. The Special Issue aims to improve decision-making processes using 3D/4D geological modeling for mineral exploration and multiple innovative methodologies and technologies (e.g., conventional explicit and implicit modeling, real-time mining and 5G+ information technology, artificial intelligence decision-making, 3D/4D simulation, and digital twin). The geological concept model can be quantitatively analyzed by typical deposit research with an exploration engineer; thus, 3D/4D models can be built, simulated, and integrated via multisource geosciences datasets or big data from the field survey and the analysis of geosciences methods. Constructing 3D/4D certainty models for mineral exploration using multiscale and multisource datasets can be challenging [1,2]; mineral resource assessment and environment protection are associated with regional mining development and strategic planning.

Lv et al. [2] used GIS technology to integrate geological information, geophysical, geochemical, and remote sensing data and then applied RBFLN model in-depth learning to carry out two-dimensional metallogenic prediction and finally successfully delineated favorable 3D target zones. It can be seen that the deep metallogenic prediction method based on machine learning provides a scientific basis for the exploration and deployment of mineral resources. Mineral resource prediction and evaluation methods are developing toward the direction of model integration and intelligent information analysis. In addition to 3D geological modeling and metallogenic prediction of solid minerals, Zhang et al. [3] applied 3D Structural Modeling (3D SM) and Joint Geophysical Characterization to hydrocarbon reservoir characterization. The results show that this method is helpful in better understanding the structural and stratigraphic characteristics of the reservoir, the spatial distribution of associated facies and the petrophysical properties to conduct reliable reservoir characterization. Liu et al. [4] discussed the mineralization and oxidation transformation process of Shangfanggou molybdenite in the supergene stage by using three-dimensional (3D) multi-parameter geological modeling and microanalysis. Meanwhile, from macro to micro, the temporal–spatial–genetic correlation and exploration constraints are also established through the 3D geological modeling of industrial Mo orebodies and Mo oxide

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orebodies. This Special Issue also includes a study on Micro-Mechanisms and Implications of Continental Red Beds by He et al. [5].

The method for deep targeting based on a stepped metallogenic model and the method for predicting the deep mineral resource potential of gold deposits based on the shallow resources of ore-controlling faults, Song et al. [6] predicted five deep prospecting target areas of the Jiaojia fault and Sanshandao fault, and the total gold resources of three ore-controlling faults, Sanshandao, Jiaojia, and Zhaoping, are about 3377–6490 tons at −5000 to −2000 m. Wu et al. [7] proposed the bi-Coons interpolation surface modeling method for an ore body model based on a set of cross-contour polylines (geological polylines interpreted from the raw geological sampling data) in his article, which can be used to effectively recover the complex ore body model from a set of cross contours polylines, providing a new technology for the establishment of the ore body model. With the development of deep prospecting, Short-Wave Infrared-spectrum 3D alteration mapping has been applied. With the rise of artificial intelligence, the combination of machine learning and geological big data has become a hot issue in the field of 3D Mineral prospectivity modeling (3DMPM) [8]. On the basis of quantitative extraction of metallogenic characteristics, Meng et al. [8], Kong et al. [9], and Yu et al. [10] constructed the deep 3D geological model of the Xuancheng-Mashan area and the deep geochemical model of the Zaozigou gold deposit, and then adopted the machine learning method to predict the deep quantitative mineral resources, and evaluated their effects. The results indicate that the machine learning method has good performance in the quantitative prediction of deep mineral resources, which is worthy of popularization and application in 3D quantitative metallogenic prediction. Li et al. [11] combined 3D spectral modeling and 3D geological modeling techniques to establish the altered mineral model and the multi-parameter model of the ore body of the Zhaoxian gold deposit in the northwestern Jiaodong Peninsula and then extracted and synthesized the metallogenic information to analyze the exploration targeting.

Abbassi et al. [12] developed a 3D statistical tool to extract geological features from inverted physical property models based on the synergy between independent component analysis and continuous wavelet transform. Multiple 3D geophysical images are also automatically interpreted by a hybrid Spectral Feature Subset Selection (SFSS) algorithm based on a generalized supervised neural network algorithm to reconstruct limited geological targets from 3D geophysical maps. Therefore, 3D geological and geophysical modeling are key exploration criteria for mineral resources [1,12].

Generally, 4D numerical simulations based on 3D geological models are used to extract the 3D exploration criteria for 3D targeting and mineral resources assessment [1]. In addition, machine learning and high-grade geostatistics can be used to extract 3D exploration criteria. It is hoped that this Special Issue is a valuable learning and research resource for anyone interested in the study of 3D/4D geological modeling research for mineral exploration and that it will serve as the basis for further research, including real-time mining and wisdom mine.

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