minerals

Editorial

Editorial for Special Issue "Geophysics for Mineral Exploration"

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Exploration geophysics plays a major role in unlocking mineral reserves. It is well recognized that many easily discovered large mineral deposits with a strong geophysical signature have already been identified. Future discoveries present significant challenges, being located undercover, in remote areas, and with less prominent geophysical signals. The modern-day challenges of exploration require developing novel geophysical techniques, which improve exploration success and lead to new discoveries.

This Special Issue contains ten papers which focus on emerging geophysical techniques for mineral exploration, novel modeling, and interpretation methods including joint inversions of multi physics data, and challenging case studies. The papers cover a wide range of mineral deposits, including banded iron formations, epithermal gold–silver–copper–iron–molybdenum deposits, iron-oxide–copper–gold deposits, and prospecting for groundwater resources.

Fu et al. [1] discuss an application of various deep-penetrating geophysical techniques to the exploration of ore deposits. In particular, they consider an important role of geophysical surveys in studying the banded iron formations (BIF). It is well known that the large-scale BIF-type iron mines represent one of the most important iron ore resources in the world. They constitute 70% of the world's high-grade iron ore reserves, and BIF-type iron mines produce over 90% of the world's iron ores. They are found all over the world, but mainly in Russia, Australia, Brazil, Canada, China, Africa, India, and the United States. They [1] present the results of integrated geophysical surveys in the Anshan-Benxi area of the North China Craton, where several major BIF-type iron deposits are located. The authors used deep-penetrating geophysical methods, including the high-precision ground magnetic survey (HPGMS), transient electromagnetic (TEM), and magnetotelluric (MT) methods. The results show that an optimal combination of these geophysical methods makes it possible to accurately determine the anomalous spatial locations and morphologies of the concealed iron ore bodies.

Alfouzan et al. [2] present the results of the Saudi Arabian Glass Earth Pilot Project. This project is a part of the geophysical exploration program to explore the upper crust of the Kingdom for minerals, groundwater, and geothermal resources. The project began with a large-scale airborne geophysical survey over approximately 8000 sq. km of green-field area, including electromagnetic (EM), magnetics, and gravity methods [3]. Based on the results of the airborne survey, several prospective mineralization targets were identified for follow-up exploration. A spectral induced polarization (SIP) survey was completed over one of the prospective targets. The field data were collected with a distributed array system, which had the potential for a strong inductive coupling (IC) effect. They [2] developed a method to fully include all 3D IC effects in the inversion of induced polarization (IP) data. The field SIP data were inverted using the generalized effective-medium theory of induced polarization (GEMTIP) in conjunction with integral equation-based modeling and inversion methods. The results of this inversion were interpreted and used to design a drill hole set up in the survey area, which intersected significant mineralization associated with gold, silver, and other base metals.

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Zhang et al. [4] applied controlled-source first-arrival tomography to study the P wave velocity structure of the Zhuxi ore deposit, located in Jiangxi province, South China. Their velocity model identified the proven orebodies, mainly related to magmatic hydrothermal activities during the Yanshanian period. These were visible as high-velocity zones, corresponding to widespread copper–iron and a few tungsten–molybdenum orebodies. These results helped to further evaluation of the total reserves, suggesting that seismic tomography could be a useful tool for mineral exploration.

Raju and Kumar [5] demonstrated how airborne and ground magnetic survey data could be effectively used for studying the Iron–Oxide–Copper–Gold (IOCG) deposits in in Gadarwara, M.P, India. They [5] showed that such deposits could be inferred from the predictive magnetic exploration models combined with geological observations and petrophysical data.

Ihbach et al. [6] examined the water potential of aquifers within in the phosphatic series in Morocco, using a combination of several geophysical methods: magnetic resonance sounding (MRS), electrical resistivity tomography (ERT), time-domain electromagnetics (TDEM), and frequency-domain electromagnetics (FDEM). They [6] demonstrated the efficiency of the MRS method for prospecting groundwater resources, and evaluated the importance in the geological context of Youssoufia open-pit mining in Morocco. The ERT method was used to delineate the conductive horizons attributed to the groundwater aquifers. The TDEM and FDEM data were used for mapping and delimiting the aquifer potential recharge zones in the phosphate series. In summary, the authors confirmed the effectiveness of the developed approach to geophysical prospecting for groundwater resources in phosphate deposits.

Two papers of this Special Issue are dedicated to developing effective methods of computer simulation of geophysical data [7,8]. Yavich et al. [7] present a novel numerical method of simulating the controlled-source audio-magnetotellurics (CSAMT) and radio-magnetotellurics (CSRMT) data, which are widely used in mineral exploration. They [7] introduced an approach to 3D electromagnetic (EM) modeling based on the new type of preconditioned iterative solver for finite-difference (FD) EM simulation. This novel preconditioner combined Green's function preconditioner and a contraction operator transformation [9]. The effectiveness of the method was illustrated by the results of numerical simulation of the CSAMT and CSRMT responses in Moscow syneclise.

Khokhlov and Stognii [8] introduced a novel approach to modeling the propagation of seismic waves in a medium containing subvertical fractured inhomogeneities, typical for mineralization zones. It was based on the use of the grid-characteristic method [10], which could model the seismic responses from subvertical fractured inhomogeneities on a structural rectangular grid. This approach significantly simplified the construction of the numerical model and the use of the algorithms. The authors presented a numerical study to illustrate the effectiveness of the developed approach to modeling the seismic wave propagation in a medium with the fractured zones.

The final three papers of this Special Issue cover novel methods of focusing migration and inversion of potential field data. Ding et al. [11] applied 3D regularized focusing migration methods to image an entire gravity survey with a focusing stabilizer. They [11] used the concept of potential field migration and image focusing, introduced in [12], for producing high resolution migration images of the subsurface density distribution. The developed method was illustrated by interpretation of the gravity data collected from the skarn-type iron deposits in Yucheng, Shandong province of China.

Meng et al. [13] discussed the ways of improving the efficiency of 3D focusing inversion of the gravity data by using preconditioned the Jacobian-free Newton–Krylov (JFNK) method. They [13] also incorporated the unstructured meshes to improve modeling of the terrain and inhomogeneous density distribution. The practical effectiveness of this novel method was shown by the case study of processing gravity data collected in Huayangchuan, Shaanxi Province of China.

The paper by Jorgensen and Zhdanov [14] presents a method of joint inversion of airborne gravity gradiometry (AGG) and total magnetic intensity (TMI) data for a shared earth model. The authors discussed two novel techniques of joint inversion; one was based on the Gramian constraints [15], and the other used the joint focusing constraints. The paper also demonstrated how Gramian constraints can be effectively used for recovering the magnetization of rock formations from TMI data. The last problem is extremely important in the presence of remanent magnetization of the rocks produced by the ancient magnetic field. The paper demonstrated the power of the technique by constructing 3D density, magnetic susceptibility, and magnetization vector models of the Thunderbird V-Ti–Fe deposit in Ontario, Canada.

In summary, the Special Issue "*Geophysics for Mineral Exploration*" provides a snap shot of advanced modeling and inversion methods of geophysical data, and their applications to studying different types of mineral deposits.

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

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