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*Editorial*

# Value of Mineralogical Monitoring for the Mining and Minerals Industry

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The shift towards lower grade ore deposits, sustainable energy, $CO_2$ reduction, volatile market conditions and digitalization has pushed the mining and minerals industry towards predictive, sustainable and agile analytical solutions to improve safety and increase operational efficiency. Therefore, fast and frequent mineralogical monitoring, geometallurgical modeling, and the prediction of process-related parameters provides value for mining operations.

Traditionally, quality control in mining industries has relied on time-consuming wet chemistry and on the analysis of elemental composition. However, the mineralogy ruling the physical properties of an ore is often monitored infrequently (if at all). The use of high-speed detectors has turned X-ray diffraction (XRD) into an important tool for fast and accurate process control, even for ores with a complex mineralogy. Recent statistical methods such as cluster analysis or partial least squares regression (PLSR) in combination with XRD raw data have become increasingly popular for handling large amounts of data and correlating process-relevant parameters directly with XRD measurements [1]. The next generation of information processing, new analytical sensors, and big data enables the use of artificial intelligence (AI) and machine learning (ML) in the mining industry to further enhance performance and efficiency.

Mineralogical monitoring is already the standard method to control and monitor processes in other industries, such as cement manufacturing [2] and aluminum smelting [3]. This Special Issue of *Minerals* demonstrates the value of its applications for the mining and minerals industry. The focus is on so-called "green metals" such as nickel, lithium, copper, aluminum and titanium. These metals will be required for energy transition in the coming years.

Nickel laterite production is on the rise and is surpassing conventional sulfide deposits. The efficiency of mining and processing nickel laterites is defined by their mineralogical composition. Mineralogy plays a key role in the production of nickel metal from nickel laterites. The value of mineralogical monitoring for grade definition, ore sorting, and processing is explained by König [4].

As lithium cannot be analyzed by X-ray fluorescence (XRF), this element is monitored by time-consuming wet chemical methods. The use of XRD for the quantitative analysis of lithium minerals and the recalculation of lithium content using statistical methods is discussed in the paper by Pöllmann and König [5]. In addition to addressing hard rock lithium ore analysis, more complex considerations on how to analyze lithium salt brines are included.

Quantitative XRD as a tool to monitor optimal blending and the detection of penalty minerals—which affect the flotation and concentration quality of copper ores—is described by Pernechele et al. [6]. The use of mineralogical monitoring for real-time decisions is discussed. The paper by Can et al. [7] on copper sulfides demonstrates the influence of

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pyrite mineralogy on the flotation process, and the possibility of developing alternative conditions to improve the performance of the process.

Available alumina and reactive silica are the main parameters controlling the beneficiation of bauxite, which is traditionally measured by laborious, expensive, and time-consuming wet chemical digestion. Alternative methods based on XRD analysis are evaluated by Melo et al. [8]. The potential of these methods industrially applied for rapid and automated quality control of bauxites is demonstrated. The use of mineralogical analysis of alumina-rich clays—covering the largest and most important bauxitic deposits of northern Brazil—as possible raw materials for the local cement and ceramic industry are discussed by Negrao et al. [9].

Heavy mineral sands are the source of various commodities, such as white titanium dioxide pigment and titanium metal. König and Verryn [10] provide information about the use of XRD to determine the composition of raw ores, heavy mineral concentrates, and titania slag. The paper highlights the importance of the fast and direct analysis of the phase composition due to the fact that the efficiency of the different process steps depends on the exact composition of the various titanium and iron phases and the different oxidation stages.

Otoijamun et al. study barite from selected locations in Nigeria [11] and aim to determine its suitability for various industrial applications. The paper shows the added value of XRD in developing beneficiation procedures, processes, and technologies for barite purification.

A systematic review concerning developing solutions based on machine learning to utilize mineralogical data in mining and mineral studies is given in the paper by Jooshaki et al. [12]. They highlight the importance of high-quality and extensive mineralogical information with respect to the increasing global demand for raw materials and evaluate the complexities of the geological structure of ore deposits and decreasing ore grades.

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