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Editorial: Advances in sustainable mine tailings management

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Editorial on the Research Topic
Advances in sustainable mine tailings management

This Research Topic focuses on progress and achievements of research in sustainable mine tailings (MTs) management. MTs are byproducts generated from mechanical and chemical processes to extract valuable elements from ore deposits. Typically, MTs are stored within tailings storage facilities (TSFs) or in the form of dry stacks. This causes a series of social, environmental, and economic problems, such as acid mine drainage and failure of TSFs. Backfill technology has been a reliable solution for sustainable MTs management. However, only a partial amount of MTs has been returned to underground voids (stopes), leaving still large amounts of MTs on the ground surface. A more worrying fact is that advanced technologies increase production from lower-grade ores in mines, yielding a higher tonnage of MTs. Sustainable recycling and reuse of MTs has become one of the major challenges in mining engineering.

To combat this challenge, interdisciplinary collaborations from fields of chemistry, physics, and material science are needed. Therefore, we called for a Research Topic on frontiers and advances in sustainable MTs management, with a view to bringing together expertise, knowledge and insights from multiple disciplines to achieve sustainable MTs disposal.

In the present Research Topic of Frontiers in Earth Science, a total of 16 manuscripts were received and 12 were accepted and published. These works cover aspects ranging from physicochemical properties of MTs, new technologies for MTs disposal, risk and stability analysis of TSFs, MTs backfill and underground environmental protection, to hydration and microstructure formation of green cementitious materials for MTs disposal.

For physicochemical properties of MTs, Chen et al. performed consolidated drained triaxial shear tests to investigate the non-linear mechanical characteristics of tailings under high pressure from high tailing ponds. They observed a linear increase in the breakage index value as the shear strength increased, suggesting that the dense region in the deeper section of the tailings dam is susceptible to particle crushing, which adversely impacts the stability of the large-scale high dam. Wang et al. conducted a comparative triaxial shear test on both pure unclassified tailings and concentrated unclassified tailings at various curing ages. They examined how the curing materials affected the shear strength of unclassified tailings and uncovered the evolution of shear strength in concentrated unclassified tailings with different curing durations.

For new technologies for MTs disposal, Wang et al. investigated the physical and chemical properties, grindability, and fundamental characteristics of ultra-fine particle iron ore tailings (IOTs), laying the groundwork for the comprehensive utilization of these IOTs in construction materials. Yuan et al. formulated a composite modifier named CMSFR, which consists of silicon calcium slag, fly ash, and reservoir sediment, to enhance the chemical and mineral composition of steel slag. Through their research, it was observed that high-temperature modification using CMSFR led to an improvement in the content of cementitious phases (C3S, C2S, C3A) and the glass phase in steel slag. The study focused on developing environmentally friendly applications of steel slag and coal-based solid waste in cement concrete. Bao et al. utilized vanadium-titanium iron ore tailings (VTIOTs) to produce high-strength fired water permeable brick (HSFWPB), and investigated the fundamental characteristics and firing process of HSFWPB incorporating VTIOTs. Additionally, an economic assessment was performed on the investment related to HSFWPB containing VTIOTs. This study holds promise in enhancing the utilization of VTIOTs and presents a novel avenue for widespread applications of VTIOTs.

For risk and stability analysis of TSFs, Chen et al. developed a predictive model for the evolution of reinforced tailings breach, incorporating an erosion model derived from the reinforced tailings erosion test and a stability analysis of the reinforced slope. Mei et al. improved the algorithm for two combined strategies involving lowering the cover plate of tailing ponds and installing additional drainage pumps. The objective was to suggest supplementary drainage measures for tailing ponds in anticipation of forecasted rainfalls. Correspondingly, they presented prediction and calculation methods utilizing fundamental data from the water level-reservoir capacity curve of tailing ponds, forecasted rainfall parameters, and flood discharge system parameters.

For MTs backfill and underground environmental protection, Han et al. conducted a study on heavy metal pollution in mine tailings, soils, and groundwater based on a database of 27 abandoned lead–zinc mine tailing sites in China. The investigation revealed a positive correlation between the content of heavy metals in soil, groundwater, and mine tailings, indicating the primary pollution source and transport pathways. The research is expected to assess the pollution levels in lead-zinc mining regions and guide remediation efforts for specific sites, thereby contributing to environmental management initiatives concerning MTs in China.

For hydration and microstructure formation of green cementitious materials used for MTs disposal, Wang et al. used steel slag, vanadium-titanium slag and vanadium-titanium iron ore tailings as the main raw materials to produce the mine cemented paste backfill material (CPBM). The composition, properties, and hydration mechanism of the new cementitious materials were analyzed. They found that the 28-day flexural strength and compressive strength of CPBM reached 4.25 and 9.41 MPa when certain conditions were met. Zhang et al. used steel slag, granulated blast furnace slag, and flue gas desulfurization gypsum after mechanical activation to prepare building foundation pit backfilling materials (BFPBM) with the coordination of iron ore tailings. They found that 28-day compressive strength and the mixture slump of BFPBM could meet the index requirements of Chinese National Standard T/CECS 1037–2022 Technical Standard for backfilling projects using premixed fluidized solidified soil.

In the paper by Guo et al., the variable head method was employed to conduct saturation permeation tests on ionic rare earth under various leaching conditions. This study revealed the impact of type, concentration, and leaching path on the saturation permeability coefficient. In the paper by Yin et al., they analyzed the correlation between indicators identifying unsafe psychological states among coal mine workers.

We believe this Research Topic builds up the understanding and knowledge of all researchers and practitioners who have interests in the recent developments and advancements in sustainable MTs management. This Research Topic informs future research on the sustainable utilization of MTs, and contributes to green mining.

Author contributions

LG: Writing–original draft, Writing–review and editing. VF: Writing–review and editing. ML: Writing–original draft, Writing–review and editing.

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Conflict of interest

LG was employed by BGRIMM Technology Group.

The remaining authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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