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Editorial

Editorial for Special Issue "Minerals and Elements from Fly Ash and Bottom Ash as a Source of Secondary Raw Materials"

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The sustainability of primary resources depends on recycling, resource efficiency and the search for alternative materials [1]. This Special Issue of *Minerals* contributes to the use of ashes as secondary raw material towards a Circular Economy, and demonstrates that the valorization of these materials is the result of complex investigations that usually require different advanced methods to be performed.

The composition of ashes is strongly influenced by the fuel composition, but the combustion conditions and the type and location of collection are also very important factors influencing the ashes' composition [2]. The combination of these factors may originate concentrations of some elements, e.g., in some ashes or in specific fractions of these, which may have the potential to be economically exploited.

For many decades, coal, biomass, and municipal solid waste ashes have been an important sustainable secondary resource for building materials [3]. However, the large volumes of these ashes generated globally every year also attracted attention to the possibility of extracting metals. For example, coal combustion fly ashes are considered to be potential sources of Al, Na, Ge, Ga, Li, REE and yttrium [4,5], while the extraction of ferrous and nonferrous metals and glass from municipal solid waste ashes has been a common practice since the 1990s [6].

This volume represents a cross-disciplinary appeal covering all aspects of fly ash and bottom ash, from their formation to their utilization as a source of secondary raw materials, and the papers by Badenhorst et al. [7], Okeme et al. [8], Hower et al. [9], Haustein and Kuryłowicz-Cudowska [10] and Guo et al. [11] contribute to show how diverse the field of research regarding coal ash can be.

The paper by Okeme et al. [8] reminds us that while being a potential secondary raw material, coal fly ash is still a material whose landfilling or utilization must take into consideration hazardous elements such as radionuclides hosted in coal minerals like uraninite, monazite and zircon, which end up concentrated in fly ash.

Many coal-burning power plants will close in the near future in Europe and the U.S. due to CO_2 regulations and the energy transition, and a shortage in coal fly ash has already been announced [12]. Therefore, a more rational and better use of coal fly in concrete is a topic of increasing interest, and the paper by Haustein and Kuryłowicz-Cudowska [10] demonstrates that investigations to improve concrete strength and decrease its porosity can still be made via characterization with advanced techniques and the use of specific size-fractions of fly ash microspheres.

The papers by Badenhorst et al. [7], Hower et al. [9] and Guo et al. [11] embrace three different themes regarding elements and materials recovering from coal fly ash. Badenhorst et al. [7] demonstrate that concentrating char from coal fly ash and its further graphitization is a challenging process since each coal, even of the same rank, produces different char, needing different means of concentration and ending with different degrees of graphitization. For example, only char concentrates with a lower proportion of anisotropic particles and a higher proportion of mixed porous particles showed greater degrees of graphitization.

The recovery of REE from coal fly ash is an increasingly important issue owing to the supply risk and the market's fluctuations, which makes the extractions of these elements from coal ash a potential way to obtain REE from a secondary raw material. However, the paper by Hower et al. [9] demonstrates that attention to the fly ash quality and the response of the fly ash to beneficiation is necessary due to variations during plants' operation, and other factors like the storage conditions at the beneficiation site.

The importance of methodological studies for the further development of the extraction of metals from coal fly ash is illustrated by the contribution of Guo et al. [11] providing a new method for extracting alumina via low-temperature potassium bisulfate calcination technology. During the process the mullite and corundum phases are degraded and the Al_2O_3 is efficiently converted into soluble $K_3Al(SO_4)_3$ at low temperature.

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