minerals

Editorial

Editorial for Special Issue "Industrial Minerals"

Maite Garcia-Valles

Departament de Mineralogia, Petrologia i Geologia Aplicada, Universitat de Barcelona, c/ Martí i Franquès, s/n, 08028 Barcelona, Spain; maitegarciavalles@ub.edu; Tel.: +34-934021348

Citation: Garcia-Valles, M. Editorial for Special Issue "Industrial Minerals". *Minerals* **2021**, *11*, 129. https://doi.org/10.3390/min11020129

Received: 12 January 2021
Accepted: 26 January 2021
Published: 28 January 2021

Industrial minerals play an important role in keeping our society running, as they are used in a wide range of industrial and domestic applications. Harben and Bates [1] define the industrial minerals as all those materials that man takes out of the Earth's crust, except for fuels, metallic ores, water, and gemstones. A commonly used synonym for industrial minerals is non-metallic minerals, and a more precise one is industrial minerals and rocks. Industrial minerals include minerals and rocks that, depending on their physical and chemical properties, are used, directly or with treatment, in the manufacturing of products, such as ceramics, glass, cement, biomaterials, and geopolymers, and even in the recycling of wastes. This definition also includes construction materials and waste products of several bulk industrial processes [2]. Compared with ore minerals, industrial minerals are cheap, as they are generally abundant, widely distributed on the Earth's surface, and are often simple to process. In addition, they involve the transport of a large volume of material, thus transport costs represent a significant portion of their price, so the industry that performs this processing is installed near the extraction.

The use of industrial minerals by industry requires that they be homogeneous. To determine the most appropriate use and optimize the processing of industrial minerals, their chemical and mineralogical composition must be rigorously controlled. Likewise, the thermodynamic behavior of minerals during processing is important (e.g., changes in compositions of phases and textures) to optimize the product properties.

This Special Issue deals with several industrial minerals such as kaolin, feldspar, and talc [3–7] and products obtained from industrial minerals as raw materials: ceramics [8], cement [9–11], and glass [12]. The last two articles focus on industrial materials as a solution to environmental problems [11,12]. Finally, an article on the use of indicator minerals is also included in this Special Issue [13].

Kaolin is one of the most important industrial minerals owing to its wide variety of applications [14]. The mineralogical and geochemical composition determine the possible use of kaolin. Cretaceous–Paleocene lateritic kaolinitic clays of Terra Alta, Catalonia, are currently exploited, however, a detailed characterization has not been previously reported; therefore, Garcia-Valles et al. [3] present a study of several quarries and outcrops to characterize these kaolinitic clays. The chemical composition, mineralogy, rheological behaviour, particle size distribution, and plasticity were characterized. The mineralogy consists of kaolinite with quartz, illite, hematite, and minor K-feldspar and calcite. One of the most important properties of kaolin is the white colour [15]. The Fe and Ti contents prevent them from being directly used as raw material for white ceramics. Most of the area comprises medium plastic clays that are classified as fired clays and can be used as ceramic and construction materials. Locally, highly crystalline and low-plastic kaolins (flint clays) occur. These kaolinitic clays can also be used to obtain a triaxial ceramic when they are mixed with feldspar to act as a fluxing agent and chamotte.

To increase the quality, kaolin is usually calcined. This process consumes a large amount of energy and the CO_2 emissions need to be controlled. Guatame-García and Buxton [4] developed a protocol to control and optimize the calcination of kaolin using infrared spectroscopy as a monitoring technique to determine the chemical properties of the calcined kaolin product. They found that the control of the soluble alumina contents in the calcinated product is the more important quality parameter.

Diko-Makia and Ligege [5] present a detailed characterization and determination of the technological properties of clays from Limpopo (South Africa) to assess their viability for structural ceramics. The chemical and mineralogical composition of raw materials from Limpopo indicates that the predominant clay is smectite, which occurs together with quartz and feldspar. Plasticity and the thermal properties were also evaluated. Characterization based on the clay workability chart, Winkler's diagram, and compositional ternary diagrams revealed that these clays have acceptable extrusion properties and are suitable for structural ceramics and earthenware.

Feldspar is an important industrial mineral. Alkali feldspars are one of the main raw materials of ceramic and glass. Therefore, it is important to know how to evaluate potential deposits of this raw material. Zahradník et al. [6] provide an exhaustive review of feldspar from the Czech Republic. The Czech Republic is a major producer of feldspar in Europe and in the world, but feldspar deposits are poorly known. Feldspar deposits occur in leucocratic granites, sedimentary rocks, and granitic pegmatites. This work promotes the feldspar deposits of the Czech Republic.

Talc is a magnesium phyllosilicate of industrial interest, mainly in the ceramic, paper, and cosmetic industries. Pi et al. [7] compare two Mexican talc deposits, from Oaxaca and Puebla, with nine other commercial talc deposits. They compare the mineralogical purity of them with respect to the price in the Mexican market. Talc from Mexican deposits are impure, with only about 70% talc. High contents of Fe, Cr, Ni, and Co make their use in the manufacture of high-quality cosmetic talc difficult. They conclude that low-cost talc should not be sold as cosmetic talc, and the regulations in Mexico on this subject should be reviewed and updated.

Sokol et al. [11] present an exhaustive geochemical and mineralogical characterization of oil shale from the Hatrurim Basin, Israel, which is a natural analogue of industrial cement clinker. The pyrometamorphic suite of minerals from the Hatrurim Formation are good for in-depth studies of clinker minerals; relatively well-crystallized grains represent the cement phases. The results can be used to better understand the mineral genesis and element partitioning during high-temperature–low-pressure combustion metamorphism of trace element-loaded bituminous oil shales as well as for understanding of the effect of multiple elements on the properties and hydration behaviour of crystalline phases in industrial cement clinkers.

The study of industrial minerals is applied in different fields, such as archaeology, where the provenance and technology of ceramics can be determined from the characteristics of the components of the ceramic pastes. In the contribution by Anglisano et al. [8], chemical groups for several local Catalan pottery production centres have been successfully defined using both local clays and baked local clays. The chemical signature of clays is linked to the original clay minerals and their trace elements. The minerals change during the firing process, but the overall chemical composition remains basically undisturbed. Common unsupervised methods such as principal component analysis (PCA) and hierarchical cluster analysis (HCA) would have failed to distinguish the different local production centres because their clays come from very similar geological formations with similar chemical and mineral composition. In contrast, the presented method allows ceramics to be tracked to a particular source with a success rate above 85%. The methodology has the potential to be applied elsewhere.

The petrography of concrete is necessary to determine the durability. Garcia et al. [10] report a detailed petrographic and chemical study of the 100-year-old Camarasa dam concrete. This concrete was made with sands and dolomitic aggregates. A detailed chemical and mineralogical characterization allows the alteration reactions to be determined. Camarasa concrete provides a natural setting to study the dedolomitization reaction in concrete, which occurs on the surface of the aggregate dolomite particles, protecting them from further dissolution. The loss of durability in this concrete is attributed to the alkali–carbonate reaction.

Sustainability is a fundamental aspect in which industrial minerals play a role. Several industrial minerals are widely used in environmental protection and remediation, whereas others are used for clean technologies, such as those involved in the battery production or in the substitution of conventional Portland cement by others with CO_2-free emission during production. Aponte et al. [11] use landle furnace slags to produce an alkaline activated mortar, and incorporate Na-silicate and Nahydroxide as activating agents. The mineralogy and physical and mechanical properties of the mortars were evaluated at different ages of curing.

The reduction and prevention of waste generation has been established as a priority of the European Union. These residues include those of mining origin, which cause a considerable environmental impact, because, in addition to occupying large areas of land, they lead to the emission of potentially toxic elements. Vitrification is a technology for the stabilization of hazardous waste as it turns them into a stable glass or glass-ceramic that is suitable for obtaining products for commercial purposes [16]. Alfonso et al. [12] use tailings from the F-Pb Osor mine, in Catalonia, Spain to make glass. These tailings are rich in Ca and only Na-rich additives are necessary to obtain a suitable glass. Ca-poor tailings require the addition of calcium [17]. The glass obtained is chemically stable and potentially toxic elements remain fixed in the glassy structure.

Zglinicki et al. [13] describe prospecting for chromian spinels in Waropen Regency, New Guinea based on indicator minerals (chromian spinel, olivine, and pyroxenes). Chromian spinels are the ore of metallurgic chromium and are also used in the chemical and refractory materials industry. The chemical composition of chromian spinels indicates that they formed from depleted peridotites in back-arc and fore-arc basins under supra-subduction conditions. Their results suggest that high concentration of Cr_2O_3 in the alluvial sediments may be a clue to finding a new potential source of chromite in New Guinea.

This Special Issue on industrial minerals includes only a few of the potential wide range of topics. The papers presented in this Special Issue provide an example of research dedicated to the characterization of some industrial minerals before and after processing.

There is a need for additional research on industrial minerals as current market demands are changing towards more sustainable products. The recycling of products made from industrial minerals deserves more research. Modern technologies increasingly use industrial minerals that must have very specific properties, resulting in more waste. I encourage researchers to broaden their studies of the industrial minerals to include sustainability.

Acknowledgments: The guest editor thanks the authors of the articles included in this Special Issue, the reviewers, and the Editorial board and Assistant Editors for their constant work on this issue.

Conflicts of Interest: The author declares no conflict of interest.

References

1. Harben, P.W.; Bates, R.L. *Industrial Minerals Geology and World Deposits*; Metal Bulletin Plc.: London, UK, 1990.
2. Kogel, J.E.; Trivedi, N.C.; Barker, J.M.; Krukowski, S.T. Industrial Minerals & Rocks, Commodities, Markets and Uses. In *Society for Mining, Metallurgy and Exploration*, 7th ed.; SME: Southfield, MI, USA, 2006.
3. Garcia-Valles, M.; Alfonso, P.; Martinez, S.; Roca, N. Mineralogical and Thermal Characterization of Kaolinitic Clays from Terra Alta (Catalonia, Spain). *Minerals* **2020**, *10*, 142. [CrossRef]
4. Guatame-García, A.; Buxton, M. Prediction of soluble Al_2O_3 in calcined kaolin using infrared spectroscopy and multivariate calibration. *Minerals* **2018**, *8*, 136. [CrossRef]
5. Diko-Makia, L.; Ligege, R. Composition and Technological Properties of Clays for Structural Ceramics in Limpopo (South Africa). *Minerals* **2020**, *10*, 700. [CrossRef]
6. Zahradník, J.; Jirásek, J.; Starý, J.; Sivek, M. Production, Reserves, and Processing of Feldspar and Feldspathoid Rocks in the Czech Republic from 2005 to 2019—An Overview. *Minerals* **2020**, *10*, 722. [CrossRef]
7. Pi-Puig, T.; Animas-Torices, D.Y.; Solé, J. Mineralogical and Geochemical Characterization of Talc from Two Mexican Ore Deposits (Oaxaca and Puebla) and Nine Talcs Marketed in Mexico: Evaluation of Its Cosmetic Uses. *Minerals* **2020**, *10*, 388. [CrossRef]

8. Anglisano, A.; Casas, L.; Anglisano, M.; Queralt, I. Application of Supervised Machine-Learning Methods for Attesting Provenance in Catalan Traditional Pottery Industry. *Minerals* **2020**, *10*, 8. [CrossRef]
9. Garcia, E.; Alfonso, P.; Tauler, E. Mineralogical Characterization of Dolomitic Aggregate Concrete: The Camarasa Dam (Catalonia, Spain). *Minerals* **2020**, *10*, 117. [CrossRef]
10. Sokol, E.V.; Kokh, S.N.; Sharygin, V.V.; Danilovsky, V.A.; Seryotkin, Y.V.; Liferovich, R.; Deviatiiarova, A.S.; Nigmatulina, E.N.; Karmanov, N.S. Mineralogical Diversity of Ca_2SiO_4-Bearing Combustion Metamorphic Rocks in the Hatrurim Basin: Implications for Storage and Partitioning of Elements in Oil Shale Clinkering. *Minerals* **2019**, *9*, 465. [CrossRef]
11. Aponte, D.; Soto Martín, O.; Valls del Barrio, S.; Barra Bizinotto, M. Ladle Steel Slag in Activated Systems for Construction Use. *Minerals* **2020**, *10*, 687. [CrossRef]
12. Alfonso, P.; Tomasa, O.; Domenech, L.M.; Garcia-Valles, M.; Martinez, S.; Roca, N. The Use of Tailings to Make Glass as an Alternative for Sustainable Environmental Remediation: The Case of Osor, Catalonia, Spain. *Minerals* **2020**, *10*, 819. [CrossRef]
13. Zglinicki, K.; Kosiński, P.; Piestrzyński, A.; Szamałek, K. Geological Prospection of Placer Chromium Deposits in the Waropen Regency—Indonesia (New Guinea) Using the Method of Indicator Minerals. *Minerals* **2020**, *10*, 94. [CrossRef]
14. Murray, H.H. Current industrial applications of clays. *Appl. Clay Sci.* **2006**, *12*, 106–112.
15. Pruett, R.J.; Pickering, S.M. Kaolin. In *Industrial Minerals and Rocks*, 7th ed.; Kogel, J.E., Trivedi, N.C., Barker, J.M., Krukowski, S.T., Eds.; Society for Mining Metallurgy and Exploration: Englewood, CO, USA, 2006.
16. Bingham, P.A.; Hand, R.J.; Forder, S.D.; Lavaysierre, A. Thermal and structural characterisation. *J. Hazard. Mater.* **2005**, *122*, 129–138. [CrossRef] [PubMed]
17. Alfonso, P.; Castro, D.; García-Vallès, M.; Tarragó, M.; Tomasa, O.; Martínez, S. Recycling of tailings from the Barruecopardo tungsten deposit for the production of glass. *J. Therm. Anal. Calorim.* **2016**, *125*, 681–687. [CrossRef]