minerals

MDPI

Editorial

Editorial for Special Issue "Mineralogy of Quartz and Silica Minerals"

Jens Götze

Institute of Mineralogy, TU Bergakademie Freiberg, 09599 Freiberg, Germany; jens.goetze@mineral.tu-freiberg.de

Received: 12 October 2018; Accepted: 17 October 2018; Published: 19 October 2018

Quartz and other silica minerals make up 12.6 wt % of the Earth's crust and belong to the most frequent rock-forming constituents. Despite the simple chemical formula SiO_2, at least 14 crystalline and amorphous silica modifications with varying crystallographic order exist which play an important role in geological as well as industrial processes [1]. In respect to the occurrence in nature and the amount of technical material used, quartz (trigonal alpha-quartz) is the most important silica phase.

The chemical and physical properties of quartz and the other silica phases are determined by their real structure. The type and frequency of lattice defects are influenced by the thermodynamic conditions during mineralization or secondary processes of alteration. Accordingly, the real structure is a fingerprint of the genetic conditions of formation. The knowledge of the interrelations between genesis and specific properties can, therefore, be used both for the reconstruction of geological processes and for specific technical applications [2].

Although quartz and silica research has a long history, the questions concerning the chemical and physical properties are far from being answered completely. However, modern analytical methods brought a lot of new mineralogical and geochemical data concerning the origin of quartz and the other silica phases. In particular, those methods which allow investigations with high resolution, low detection limits or spatially resolved analyses (e.g., electron microscopy, trace element analysis, electron paramagnetic resonance spectroscopy, infrared spectroscopy or cathodoluminescence) are useful for the extension of the state of the art. The contributions of this special issue of *Minerals* clearly demonstrate that complex investigations by a combination of different advanced methods will have the greatest potential for the successful completion of upcoming geological or industrial problems.

The papers by Götze et al. [3], Lin et al. [4], Pei et al. [5] and Guatame-Garcia and Buxton [6] impressively demonstrate how advanced analytical methods are being used for the characterization of mineral properties and how this knowledge can be used for processing. The material that was investigated in these studies includes high-purity quartz from metamorphic host rocks, hydrothermal vein quartz, as well as diatomite. The results of the investigations emphasize that a thorough mineralogical and geochemical characterization of different kinds of SiO_2 raw materials is indispensable for the successful use of high-quality materials in the industry.

Another topic covers several complex investigations concerning the reconstruction of the formation conditions of different types of SiO_2 mineralization. In their contribution about silica colloid ordering in a dynamic sedimentary environment, Liesegang and Milke [7] show how ordered arrays of amorphous silica spheres form in deeply weathered sediments. The formation of such ordered particle arrays not only takes place in inorganic photonic structures in the geosphere, however is also important for nanotechnology and biological systems. Other formation environments for quartz and silica minerals are discussed by Müller et al. [8], Voudouris et al. [9] and Trümper et al. [10]. Spectacular quartz crystals of various colours and habits were reported from a hydrothermal breccia of Berglia-Glassberget, Norway [8] and also in volcanic rocks in different occurrences of Greece [9]. Both papers try to reconstruct the specific conditions leading to the formation of the quartz crystals based on thorough mineralogical and geochemical analyses (trace elements, fluid inclusions, oxygen isotopes). Trümper et al. [10] studied fossil wood from five late Paleozoic settings using field observations, taphonomic determinations as well as mineralogical analyses to reconstruct the silicification process. The results indicate that silicification is sometimes a monophase, however it is often a multiphase process under varying physico-chemical conditions.

Other studies in the present book show how the knowledge about the processes of SiO_2 mineralization can also help to decipher the origin of gold deposits and provide information about the mineralization conditions. Taksavasu et el. [11] found implications for the formation of bonanza veins in low-sulfidation epithermal deposits from the textural characteristics of non-crystalline silica in sinters and quartz veins. Wertich et al. [12] developed a multi-stage model of gold-bearing hydrothermal quartz veins at the Mokrsko gold deposit (Czech Republic) based on cathodoluminescence and trace element data. Based on the results of such studies, the prognosis of potential gold deposits could be significantly improved.

The importance of methodological studies for the further development of analytical methods is illustrated by two contributions providing new data concerning thermogravimetry-mass-spectrometry [13] and cathodoluminescence microscopy and spectroscopy [14], respectively. Richter-Feig et al. [13] studied volatile components in micro- and macro-crystalline quartz of agates (chalcedony) and used these data for the reconstruction of the kind and composition of mineralizing fluids of these spectacular forms of silica. In the study by Sittner and Götze [14], defects and micro-textures of quartz in different metamorphic rocks from the Kaoko belt (Namibia) representing metamorphic zones from greenschist to granulite facies were analyzed by cathodoluminescence. The results illustrate that the cathodoluminescence properties of quartz can also be used to get information about the conditions of mineral formation.

The book content is completed by a review article of Kayama and co-authors [15] about Lunar and Martian silica phases. Although silica polymorphs, such as quartz, tridymite, cristobalite, coesite, stishovite, seifertite, high-pressure silica glass, moganite or opal, are relatively rare in extraterrestrial materials, the occurrence of these phases can provide valuable information about different pressure and temperature conditions. Thus, igneous processes (e.g., crystallization temperature and cooling rate), shock metamorphism (e.g., shock pressure and temperature) or hydrothermal fluid activity can be reconstructed based on the presence and properties of specific silica phases, implying the importance of SiO_2 minerals in planetary science.

All of these examples show that the knowledge of the relationships between the genetic conditions of the formation of silica phases and the development of specific properties is an important factor in geological research as well as in many technical applications. Therefore, it is my hope that this special issue is a valuable and substantive resource for anyone who is interested in studies of quartz and silica minerals and that it will serve as a basis for further research.

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

References

1. Götze, J. Chemistry, textures and physical properties of quartz—Geological interpretation and technical applications. *Mineral. Mag.* **2009**, *73*, 645–671. [CrossRef]
2. Götze, J.; Möckel, R. *Quartz: Deposits, Mineralogy and Analytics*; Springer Geology: Heidelberg, Germany; New York, NY, USA; Dordrecht, The Netherlands; London, UK, 2012; p. 360. ISBN 978-3-642-22160-6.
3. Götze, J.; Pan, Y.; Müller, A.; Kotova, E.; Cerin, D. Trace Element Compositions and Defect Structures of High-Purity Quartz from the Southern Ural Region, Russia. *Minerals* **2017**, *7*, 189. [CrossRef]
4. Lin, M.; Pei, Z.; Lei, S. Mineralogy and Processing of hydrothermal vein quartz from Hengche, Hubei Province (China). *Minerals* **2017**, *7*, 161. [CrossRef]
5. Pei, Z.; Lin, M.; Liu, Y.; Lei, S. Dissolution Behaviors of Trace Muscovite during Pressure Leaching of Hydrothermal Vein Quartz Using H_2SO_4 and NH_4Cl as Leaching Agents. *Minerals* **2018**, *8*, 60. [CrossRef]

6. Guatame-Garcia, A.; Buxton, M. The Use of Infrared Spectroscopy to Determine the Quality of Carbonate-Rich Diatomite Ores. *Minerals* **2018**, *8*, 120. [CrossRef]
7. Liesegang, M.; Milke, R. Silica colloid ordering in a dynamic sedimentary environment. *Minerals* **2018**, *8*, 12. [CrossRef]
8. Müller, A.; Ganerød, M.; Spjelkavik, S.O.S.S.; Selbekk, R. The hydrothermal breccia of Berglia-Glassberget, Nord Trøndelag, Norway: Snapshot of a Triassic earthquake. *Minerals* **2018**, *8*, 175. [CrossRef]
9. Voudouris, P.; Melfos, V.; Mavrogonatos, C.; Tarantola, A.; Götze, J.; Alfieris, D.; Maneta, V.; Psimis, I. Amethyst occurrences in Tertiary volcanic rocks of Greece: Mineralogical, fluid inclusion and oxygen isotope constraints on their genesis. *Minerals* **2018**, *8*, 324. [CrossRef]
10. Trümper, S.; Rößler, R.; Götze, J. Deciphering silicification pathways of fossil forests: Case studies from the late Paleozoic of Central Europe. *Minerals* **2018**, *8*, 432. [CrossRef]
11. Taksavasu, T.; Monecke, T.; Reynolds, T.J. Textural characteristics of non-crystalline silica in sinters and quartz veins: Implications for the formation of bonanza veins in low-sulfidation epithermal deposits. *Minerals* **2018**, *8*, 331. [CrossRef]
12. Wertich, V.; Leichmann, J.; Dosbaba, M.; Götze, J. Multi-stage evolution of gold-bearing hydrothermal quartz veins at the Mokrsko gold deposit (Czech Republic) based on cathodoluminescence, spectroscopic, and trace elements analyses. *Minerals* **2018**, *8*, 335. [CrossRef]
13. Richter-Feig, J.; Möckel, R.; Götze, J.; Heide, G. Investigation of Fluids in Macrocrystalline and Microcrystalline Quartz in Agate Using Thermogravimetry-Mass-Spectrometry. *Minerals* **2018**, *8*, 72. [CrossRef]
14. Sittner, J.; Götze, J. Cathodoluminescence (CL) characteristics of quartz from different metamorphic rocks of the Kaoko belt (Namibia). *Minerals* **2018**, *8*, 190. [CrossRef]
15. Kayama, M.; Nagaoka, H.; Niihara, T. Lunar and Martian Silica. *Minerals* **2018**, *8*, 267. [CrossRef]