

Editorial

Editorial for Special Issue “Agates: Types, Mineralogy, Deposits, Host Rocks, Ages and Genesis”

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Agates are famous, beautiful, and fascinating stones found all around the world. They are classically associated with volcanic rocks but can be found in sedimentary, metamorphic, and igneous environments. Although agates are composed almost entirely of SiO_2 , it is the trace quantities of various other elements that give agates their color and lead to their characteristic banding. Despite many in-depth studies and improving analytical and investigative methods, the source of the silica required for the growth of agate remains largely unknown. The first known descriptive reports about agates are from the 18th century. Serious scientific investigations concerning the chemical composition properties and genesis of agates started in the middle of the 19th century. As a result of these numerous studies, a wide spectrum of theories about the formation of agates exists today. The complex, multi-step process of agate formation is not yet completely understood. The aim of this Special Issue is to bring together researchers from different countries to further our understanding of the genesis of agates.

The Special Issue “Agates: Types, Mineralogy, Deposits, Host Rocks, Ages and Genesis” contains two reviews [1,2] and six research articles devoted to detailed studies of agates from Morocco [3], China [4], Russia [5–7], and Cuba [8].

This Special Issue was prepared during the 2020 and 2021 COVID-19 pandemic. Terry Moxon [2] died on 5 January 2021, from COVID-19. He was one of the leading scientists in the research of agates, an excellent reviewer, and a responsible coauthor. Evgeny Sidorov [7] died on 20 March 2021, of complications from COVID-19. He was a very bright, reliable, positive, creative, extraordinary, kind, generous, and wise person as well as an exceptional organizer. I dedicate this Special Issue to Terry Moxon and Evgeny Sidorov.

The review by Götze et al. [1] is an outstanding contribution to this Special Issue. Their paper provides a comprehensive compilation of mineralogical and geochemical data of agates from worldwide occurrences in different host rocks and summarizes the results of extensive studies on agate samples of different origin and type. This article is an excellent introduction to agates for potential researchers who want to study them. Their paper covers almost the entire spectrum of agate problems. Götze et al. [1] provide a preliminary model of agate formation. According to their model, agates begin as silica sols and amorphous silica from silicic acid. Crystallization begins with non-equilibrium spherulitic growth of chalcedony. The banding and colors in agate are “governed by processes of self-organization” with differences due to factors such as porosity, crystallite size, kind of silica phase and incorporated color pigments.

Moxon and Palyanova [2] present a thorough review of the genesis of agates in basic volcanic rocks including relevant literature covering the last 250 years. This review covers research on agate from 1770 to the present, which during this time evolved from physical observations of host rocks and agate thick sections to the sophisticated modern analytical determination of physical and chemical properties. They conclude that agates in mafic igneous rocks form at $<100^\circ\text{C}$. The precursor to agate is amorphous silica, and agates continue to change over long periods of time, ending with the formation of microcrystalline quartz. They recommend studies of agates hosted by very young rocks.



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Pršek et al. [3] report new data on agates from Asni and Agouim (Western Atlas Morocco) and compare their results with previous studies of nearby localities Sidi Rahal and Kerrouchen (Atlas Mountains, Morocco). The authors identified the similarities and differences between agates from these four localities in Morocco. They concluded that the possible sources of silica-bearing fluids were related to the syn- and post-volcanic alteration of the host rocks.

Zhang et al. [4] studied Zhanguohong agates from Beipiao, Liaoning Province (China), hosted by intermediate-felsic volcanic breccia of the Early Cretaceous Yixian Formation. The authors document that the color of the agate changes from yellow, to orange, and then to red when the hematite content increases and the goethite content decreases. They provide a model of the formation process of the rhythmic banding in Zhanguohong agates connected with the fluctuations in the moganite and α -quartz contents and the zonation of the Fe-bearing particles (mixtures of hematite, goethite, and silica phases).

Svetova and Svetov [5] investigated Onega agates from the Paleoproterozoic volcanic complex on the Southeast Fennoscandia (Russia) within the Onega Basin. Agate mineralization is widespread in amygdules and in inter-pillow void spaces of basalts, picobasalts, basaltic andesites, and agglomeratic tuffs. The authors reconstruct the possible conditions for the formation of Onega agates. They propose that the agates formed during the Paleoproterozoic from the hydrothermal fluid of magmatic and/or meteoric waters are associated with gabbro-dolerite sills.

Svetova et al. [6] provide the first detailed investigations of black agates hosted by volcanic rocks of the Zaonega Formation within the Onega Basin (Karelian Craton, Fennoscandian Shield, Russia). Black agates are rare in nature. The authors describe three main texture types of black agates: concentrically zoned, spherulitic, and mossy. They demonstrate that disseminated carbonaceous matter associated with (fibrous) chalcedony or fine-grained quartz is the major coloring agent. They propose that the source of carbonaceous matter in agates is from underlying carbon-bearing shungite rock, which was redistributed by the Paleoproterozoic hydrothermal system.

Palyanova et al. [7] present the results of studies of the copper-containing agates from the Avacha Bay (Eastern Kamchatka, Russia). They determine that the copper minerals in agates from this location are native copper, cuprite, and various copper sulfides (chalcocite, djurleite, digenite, anilite, yarrowite, and rarely chalcopyrite). Sphalerite, native silver, and barite are also found in these agates. The native copper crystallized simultaneously with early silica. Copper sulfides in the pore and interstitial space of spheroid-layered silica aggregates and cuprite and barite microveins indicate their later deposition. Fluid inclusions suggest that the agates formed at temperatures of $<110^{\circ}\text{C}$ from very low salinity (<0.3 wt.% NaCl equivalent) solutions.

Götze et al. [8] investigated agates hosted by Paleocene/Eocene tuffs from El Picado/Los Indios, Moa region (the Eastern part of Cuba). The agates consist of high amounts of opal and moganite. Surficial alteration of basic volcanic rocks provides abundant silica for the crystallization of agates in fissures and cavities of the volcanic host rocks from heated meteoric waters.

I hope all the articles in this Special Issue will be a helpful and valuable resource for anyone who is interested in the genesis of agates and will provide a foundation for further research.

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