Mineralogical characteristics of agates and their host rocks in Chihuahua, Mexico

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Agates from the state of Chihuahua in Mexico are known worldwide among collectors and jewelry dealers because of their color variety and high quality. The single deposits are limited to different areas which are distributed in the whole federal state of Chihuahua. The agates of the different localities partly differ in their basic coloring as well as in their general appearance and the abundance of pseudomorphs. Despite the wide distribution and individual locality-typical characteristics, most of the best-known deposits can be assigned to the same volcanic unit, the so-called Rancho el Agate Andesite. This is an approximately 300 m thick unit of intermediate lava flows, which all have a strongly vesicular texture (Keller et al. 1982). The host rocks for most of the presently mined agate deposits in the main production area of the Sierra del Gallego can be classified almost exclusively as quartz-free latite (Mrozik et al. 2023). The intermediate chemism of the rocks can be explained by a mixing of magmas with different SiO_2 contents.

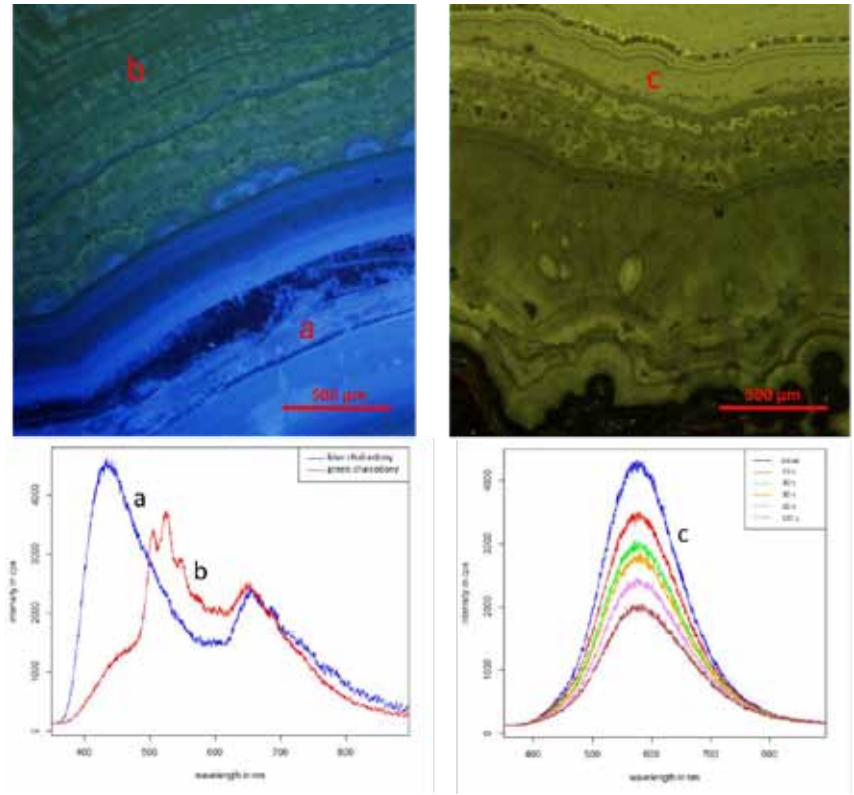

Figure 1. CL-micrographs with the associated CL-spectra. The CL-colors and spectra reveal different structural defects as well as the incorporation of trace elements and compounds like for example the uranyl-ion within the green luminescent parts of the chalcedony. (Figure from Mrozik et al. 2023)

Different reasons for the coloration of the agates could be determined by various spectroscopic methods as well as with trace element analyses and microscopic studies. While different structural defects can be detected in many areas of the mineralization (Fig. 1) the coloration of most of the bands in the agates is caused by inclusions, for example hematite and goethite. The different colors are not exclusively caused by the mineral phase but also by the particle size as well as the distribution of the coloring components within the matrix of the chalcedony. Some of these inclusions were incorporated within the agates during the initial crystallization of the chalcedony, others were later fixed within the matrix by secondary infiltration (Fig. 2) (Mrozik et al. 2023).

A mixture of near-surface weathering solutions with deep hydrothermal fluids from the Tertiary volcanism has led to the formation of the agates. The enrichment of differently mobile elements which were fixed during the formation of the agates in the structure of the chalcedony itself as well as in the paragenetic inclusions indicate the involvement of hydrothermal fluids. Due to the very different contents of under weathering conditions rather immobile elements like zirconium and chromium as well as almost exclusively hydrothermally accumulated elements like antimony and zinc a variable influence of deep hydrothermal fluids in the different agate occurrences can be assumed. Thus, the local differences in the agate formation are not caused by a basically different formation process but by a various influence of the respective fluids as well as slightly different local geochemical conditions. In the current studies different generations of chalcedony could be determined within the mineral formations (Fig. 2) which indicates that many of the agates were not formed by a single geochemical process but underwent a multiphase formation with partly different fluids under slightly differentiated conditions. (Mrozik et al. 2023)

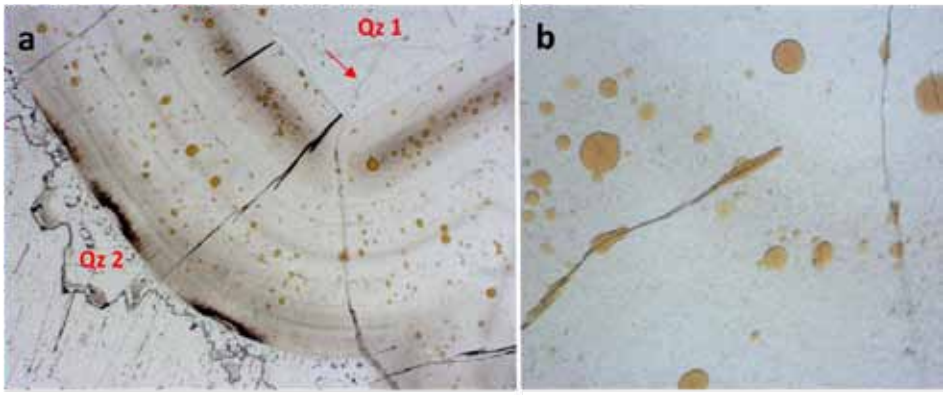

Figure 2. (a) The micrograph shows different generations of the SiO_2-mineralization with at least two generations of macrocrystalline quartz (Qz 1, Qz 2). The red arrow marks a secondary crack which can be followed within the first generation but ends at the second generation of quartz. (b) The micrograph shows a detailed view of the same agate which shows the distribution of different inclusions within the chalcedony matrix. Note that some of the inclusions are arranged along secondary cracks, which assigns a later formation of some of the coloring particles by infiltration. (Figure from Mrozik et al. 2023)

Mrozik M, Götze J, Pan Y, Möckel R (2023): Mineralogy, Geochemistry and Genesis of Agates from Chi-huahua, Northern Mexico. - Minerals 13, 687, https://doi.org/10.3390/min13050687

Keller PC, Bockoven NT, McDowell FW (1982): Tertiary volcanic history of the Sierra del Gallego area, Chihuahua, Mexico. - Geol Soc Amer Bull 93, 303-314