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Structural state of microcrystalline opals: A Raman spectroscopic study

Albena Ilieva,[1] Boriana Mihailova,[2,*] Zdravko Tsintsov,[1] and Ognyan Petrov[1]

[1]Central Laboratory of Mineralogy and Crystallography, Bulgarian Academy of Sciences, Acad. G. Bonchev Street 107, 1113 Sofia, Bulgaria
[2]Mineralogisch-Petrographisches Institut, Universität Hamburg, Grindelallee 48, D-20146 Hamburg, Germany

Abstract

The structure of natural hydrous silica is complex and its study requires the complementary application of several methods. To elucidate the structural state of opaline silica of different geneses, microcrystalline opals from siliceous rocks, geodes, and bentonite clays from East Rhodopes, Bulgaria, were analyzed by Raman spectroscopy, X-ray powder diffraction, electron microscopy, and thermogravimetric and differential thermal analysis. Comparison of X-ray diffraction and spectroscopic data for a series of microcrystalline opals showed that the fraction of tridymite-like structural units can be estimated using the relative intensity of the Raman scattering near 350 cm^{-1}. Opals displaying an intense, poorly resolved Raman band centered near 330–360 cm^{-1} contain a larger proportion of nanosized spatial regions with tridymite-type atomic arrangements as opposed to cristobalite-type arrangements. The results demonstrate the ability of Raman spectroscopy to characterize the fine-scale structure of opal and to better distinguish opals showing similar XRD patterns. The application of Raman micro-spectroscopy showed that on intermediate-range scale the atomic structure of opal lepispheres is closer to the framework topology of tridymite than to that of cristobalite.

Keywords: Opal, Raman spectroscopy, lepispheres, cristobalite, tridymite