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Australian sedimentary opal-A and its associated minerals: Implications for natural silica sphere formation

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Abstract

The vast majority of precious opal on the world market comes from opal fields in the Great Artesian Basin of Australia pointing to very special prerequisites for amorphous silica to consolidate in a way that leads to the famous play-of-color. We analyzed 20 opal-A samples from the Andamooka (South Australia) and Yowah (Queensland) precious opal fields, using petrographic microscopy, XRPD, SEM, and EPMA to identify and characterize opaline silica, the mineral assemblage, and the host rock. Opal-A consists of submicrometer-sized silica spheres with an average diameter of 140–320 nm. The average diameter of monodisperse spheres is 140–290 nm with a relative standard deviation (RSD) of <6%. Polydisperse spheres show an average diameter of 160–320 nm with a RSD larger than 10%. This dichotomy in size is reflected by the Na/K ratio at both localities. Monodisperse spheres show values below 1.2 while polydisperse ones show a ratio larger than 3.0, whereas other contaminations with higher valence show no correlations at all. We therefore suggest that the jump in Na/K signals a fundamental change of pH and salinity of the silica-bearing mineralizing fluids. Judging from the pH stability of the host rock minerals with predominating alunite, kaolinite, illite and gypsum, and omnipresent barite and anatase we conclude that the dominant late-stage mineralization leading to precious opal happened at acidic pH. Our findings indicate that the host rocks and associated minerals are the key to unravel the complex history of opal-forming solutions. A quantitative opal classification based on sphere diameters and their variability, decoupled from gemological properties, is to be established.

Keywords: Opal-A, mineral chemistry, host rock, sphere size distribution, petrogenesis, Australia