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ORIGINAL ARTICLE

Hydrochemistry and microbialites of the alkaline crater lake Alchichica, Mexico

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Abstract The structure, mineralogy, and accretion processes of the modern and subfossil cyanobacterial microbialites from the alkaline crater lake Alchichica (Puebla, Mexico) were studied, along the lake's bathymetry and hydrochemistry. The recent lowering of the lake level had exposed microbialitic carbonate mounds and crusts, which emerged up to 2 m above the water surface, while accreting cyanobacterial microbialites were present down to a depth of ~15 m. Morphological and molecular analysis found that the living cyanobacterial mats were composed of diverse filamentous and coccoid cyanobacteria (Nostocales, Chroococcales, Oscillatoriales, and Pleurocapsales). The emerged subfossil microbialites comprised two generations: "white" (domes and crusts composed mainly of hydromagnesite with an admixture of huntite and calcite, $^{238}U/^{230}Th$ age of ~2.8 ka BP), and "brown" (chimneys, columns and laminated crusts composed of aragonite with an admixture of Mg-calcite, $^{238}U/^{230}Th$ age of ~1.1 ka BP). The significant age, structural, mineralogical, and isotopic differences suggest that the two generations were formed in different environmental conditions: the "white" during a dry period, and the "brown" in wet climate associated with high water level and intense inflow of ground water, which lowered the Mg/Ca ratio resulting in formation of aragonite instead of hydromagnesite. The hydromagnesite, replacing the primary aragonite precipitated in the living cyanobacterial biofilm, frequently undergoes silicification, which obliterates both the primary structure of the carbonate and the enclosed remains of cyanobacterial microbiota. This process helps to explain the abundant formation of dolomites and cherts in an allegedly highly alkaline Early Precambrian ocean. Thus, Lake Alchichica represents a modern alkaline environment where biosedimentary structures resembling Precambrian deposits are generated.

Keywords Microbialites · Cyanobacteria · Hydromagnesite · Molecular taxonomy · Carbonate chemistry · Lake Alchichica · Mexico

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Introduction

Carbonate rocks are important components of marine deposits throughout Earth's history. The process of their formation significantly influenced the chemical evolution of atmosphere and hydrosphere, and, consequently, biosphere evolution (e.g., Holland 1984; Kempe and Degens 1985; Kempe and Kazmierczak 1994; Lowe and Tice 2004; Ohmoto 2004). Archean carbonate deposits enclose only few remains of microorganisms, which nevertheless indicate that microbial ecosystems, for example cyanobacterial mats, were involved in their origin (e.g., Walter 1983; Kazmierczak and Altermann 2002; Altermann and