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Disentangling the mechanisms behind microbialite formation in an extreme lacustrine setting: Laguna de los Cisnes (Chile)

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The process of organomineralization encompasses a wide diversity of eukaryotes and prokaryotes. These organisms have been fundamental to the development of microbialites throughout geological times. However, the paucity of detailed investigations of actively accreting microbialites still prevents the complete understanding of the different factors ruling their formation. These uncertainties are particularly true in extreme environments that represent the best modern analogues of primitive terrestrial conditions. Laguna de los Cisnes located in Chilean Tierra del Fuego, Patagonia, provides us with a unique site to fill this gap. Since the deglaciation, microbial mats have densely colonised this shallow and hypersaline lake producing both fossil and modern microbialites. These organo-sedimentary deposits have an extension of almost 8 km^2 encompassing several macro-morphologies with maximum heights and widths of 1.5 m and 5.0 m, respectively. Field observations indicate that the green algae *Percursaria percusa* is dominant, developing either at the top of the water column as floating biofilms together with cyanobacteria and diatoms, or on the surface of sediments rich in sulfate-reducing bacteria (SRB) as filaments partially degraded. Detailed microscopic and elemental observations of both living and cultured microbial and algal communities allow us to better understand the formation paths of these carbonate buildups. Based on these data, we propose a model of the different stages of mineral formation. The precipitation of Amorphous Calcium Carbonates (ACC) follows the degradation of dead filaments of *Percursaria percusa* deposited on the bottom of the lake. Subsequently, the agglomerates of metastable ACC nanoparticles gradually recrystallise, elongating in a preferential direction. In the next step, these nanoparticles eventually converge to form well-developed crystals of monohydrocalcite of a few microns. Because this mineral is metastable under Earth surface conditions, is further transformed into aragonite which is a polymorph of anhydrous $CaCO_3$. This first carbonate generation creates the framework of the buildups, which is subsequently covered by other Mg-rich mineral phases following a different formation path.

The occurrence of extraordinary well-preserved fossil outcrops along with living microbialites allows a direct comparison in order to validate this model, which could be further applied to other microbialites outcropping at different geographical and temporal scales.