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Preservation of biosignature fabrics in an extinct, variably recrystallized sinter mound, El Tatio, Chile

MARK A. VAN ZUILEN[1], DYLAN WILMETH[2], SAMI NABHAN[3], MORITZ LIESEGANG[4], SILVINA SLAGTER[5], PIERRE SANS-JOFRE[6], MARTIN HOMANN[7], KURT O. KONHAUSER[8] AND CAROLINA MUNOZ-SAEZ[9]

[1]Geo-Ocean CNRS/Univ.Brest/Ifremer
[2]Grand Valley State University
[3]University of Southern Denmark
[4]RMS Foundation
[5]Yale University
[6]IMPMC, CNRS, Sorbonne Université, MNHN
[7]University College London
[8]University of Alberta
[9]University of Nevada Reno

Presenting Author: mark.vanzuilen@univ-brest.fr

Silica sinters are surface expressions of geothermal activity, produced when amorphous silica (opal-A) precipitates via cooling and evaporation from hot, silica-saturated subsurface water that is discharged by geysers and hot springs. Microbial communities are ubiquitously present in these geothermal settings, where they become entombed in silica, creating microfossils, fabrics, and macroscopic layered structures that all can act as biosignatures. Geothermal silica sinters, therefore, form important modern analogues for remnants of life in Precambrian chert deposits. However, it is important to carefully study the preservation potential of these different biosignatures. Here we present a 3-dimensional diagenetic reconstruction of a microbial ecosystem preserved in silica sinters around an extinct geyser in the El Tatio geothermal field, Atacama Desert, Chile. A set of cores were drilled that traversed the sinter at various distances from the vent. We describe here the sedimentary facies, geochemical composition, biosignature fabrics, and variation in diagenetic silica phases of these cores. The sinter mound started forming 11,000 years ago, recording at least 3,000 years of sinter deposition on top of glacial sandstones. Facies adjacent to hydrothermal vents are dominated by laminated sinter crusts with sparse microbial preservation, while outer mound margins contain extensive sinter columns, precipitated during repeated cycles of pool overflow and subsequent evaporation. The surrounding distal aprons are dominated by palisade, tufted, and arborescent microbial fabrics, with distinct mat textures revealing well preserved microfossils. Overall, a suite of sinter depositional facies could be recognized that contain clearly defined biosignature fabrics. X-ray diffraction and SEM revealed that the sinter mound has experienced a complex history of diagenesis, with spatial variations in (re)crystallization, dissolution-reprecipitation and cementation. In particular, cementation caused the formation of small sinter pockets that were isolated from diagenetic fluid circulation, allowing the preservation of primary sedimentary structures and textures. Combined, this work shows the importance of local variability in diagenesis for the preservation of biosignatures.