Looking for Life in the Sinter Deposits of Pampa-Lirima, Chile: A New Mars Analog Setting

Constanza Nicolau [a] and Jennifer G. Blank [b]

INTRODUCTION

High concentrations of amorphous silica in Gusev Crater detected by the MER rover Spirit have been interpreted to be deposited from neutral, silica-rich hydrothermal solutions in thermal settings [1,2]. On Earth, these types of environments often support a thriving microbiome. Therefore, studying the microbial textures preserved in active hot spring-systems on Earth may be relevant toward understanding habitable environments on ancient Mars.

Here, we present initial observations of sinter deposits from a hot spring pool at Pampa-Lirima, a thermal spring environment in northern Chile (Fig. 1). Prior Mars analog studies of chilean settings have focused on the high-altitude, arid Atacama desert and the El Tatio geothermal system therein [3]; Pampa-Lirima is further North and has a smaller surface expression and slightly lower elevation than El Tatio, though it experiences similar (140.4 mm) annual rainfall [4].

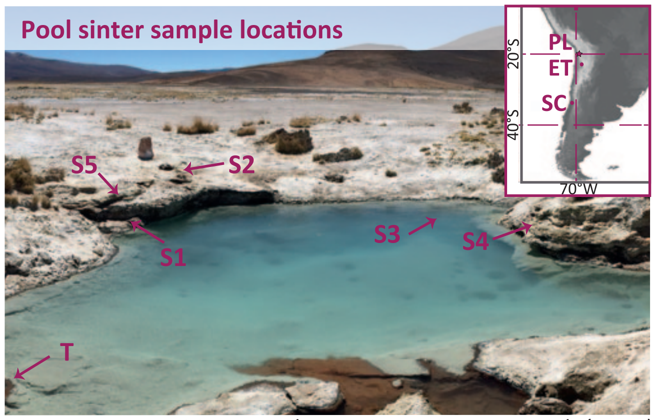

Figure 1. Pampa Lirima Sample Locations. Sinter materials (S1-S5) were collected from the border of a large (~7 m diameter) thermal pool and adjoining ~1.5m deep x 15m long trench. Brown microbial mat borders the edge of the pool and the surrounding area is white with salt and sinter debris. Insert map shows the location of PL=Pampa-Lirima, ET=El Tatio and SC=Santiago city.

Pool description

Measured pool characteristics: Elevation = 4000 m ; T = 51.5°C; pH = 7.5; Cl = 270 mg/L ; TDS = 1.45 mg/L.
Subaerial sinter has horizontal, continuous banding, while subaqueous sinter is massive and forms ledges around of the pool (Fig. 1). Samples from the pool and the trench were analyzed and compared for mineralogical and biological diversity.

RESULTS

Pool sinter

Samples are comprised of 0.25-2.5 µm diameter smooth opal-A spheres. Their structure is generally porous with diatoms cemented by opal-A, and locally massive sections of botryoidal opal-A. Diatoms constitute up to 80% of the rock. Only subaerial sample S2, taken from a fumarole near the edge of the pool, exhibits an accessory phase, gypsum. It occurs forming crusts, tabular crystals, and acicular crystals (Fig. 2).

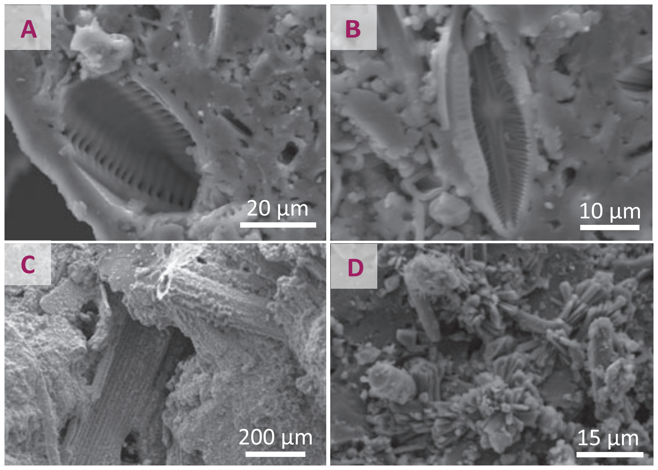

Figure 2. Mineralogy and biotic components of pool samples. A, B: Well preserved diatom casts of variable sizes cemented by opal-A smooth spheres. C: Silicified plant/reeds embedded in massive sinter. D: Prismatic, radiating gypsum crystals over massive sinter.

Trench sinter

All samples throughout the column are comprised of botryoidal opal-A spherules with minor sulfates. The microstructure is fragmental; fragments constitute 10-80% of the rock. Biotic features include generally intact diatom tests (15-80% of the rock) and 10-300 µm diameter filamentous features, presumed to be plan matter replaced by opal-A (Fig. 3).

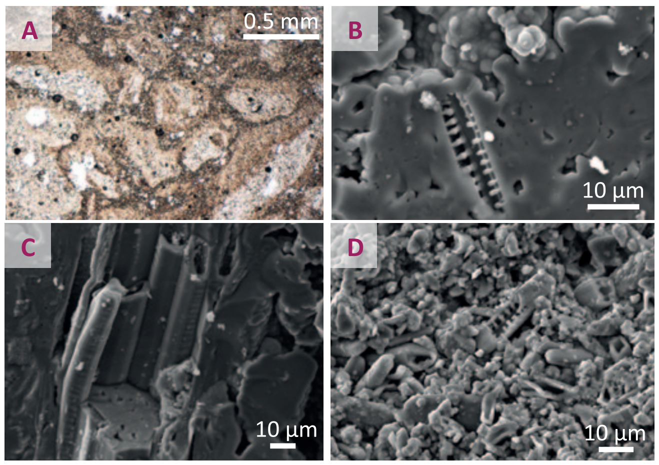

Figure 3. Trench sinter microtextures and biotic features. A: Sinter fragments cemented by opal-A, at the base of the trench. B: Sinter formed by 80% of diatom casts. C: parallely alligned biotic (microbial?) features ~10 µm diameter. D: symmetrical, biraphid diatoms embedded in botryoidal opal-A.

At the top of the column, sinter is massive to fragmental, and fragments are generally well-rounded. Accessory minerals consist of gypsum and Na-sulfate (mirabilite/thenardite?; Fig. 4 B, C). At the base, the deposit is comprised of angular sinter fragments cemented by opal-A. Accessory minerals are Na-Ca-sulfates, possibly glauberite and thenardite (Fig. 4 D, E).

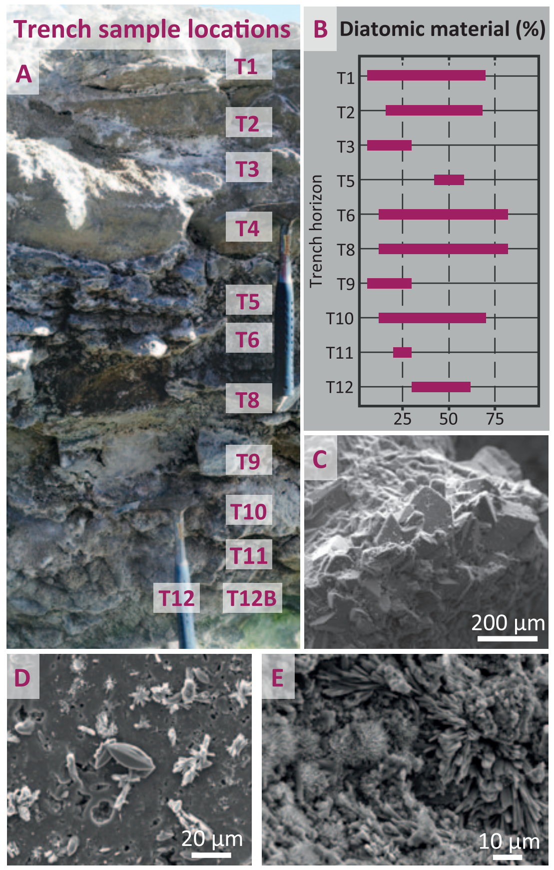

Figure 4. A: Sinter laminations in the 1.5 m deep trench to the NW of the pool. Sinter samples T1-T12 were analyzed. B: Schematic graph showing abundance of diatoms along the trench. C: Prismatic and twinned gypsum in T1. D: Prismatic and acicular, radiating Na-sulfates (mirabilite/thenardite?) in T9. E: Prismatic, radiating Na-Ca-sulfates (glauberite?) and lenticular Na-sulfates (thenardite?) in T11.

CONCLUSIONS

Pampa-Lirima is a unique planetary analog environment due to the large proportion of diatoms in the sinter deposit. The pool and trench sinter samples have similar mineralogy and biotic components, indicative of similar environmental conditions throughout the entire time of deposition. Sinters have high fractions of diatom tests, intact and fragmented. Na-sulfates found in the lower trench samples may record a period of high evaporation rate early in the depositional record.

Pampa-Lirima sinters present a higher proportion of diatoms and lower abundance of filamentous microbes compared to El Tatio [5]. Plant remains are highly abundant.

The ocurrence of diatoms and fragmental sinter could record a lacustrine environment, such as the Holocene paleo-lakes mapped to the east of Lirima [6], superimposed on the hot-spring setting. Further characterization of diatoms better constrain the depositional history of the area.

Acknowledgements: We thank J. Clavero for his help during the initial stages of this project. We thank Julio Ticuna, Freddy Cáceres, Héctor Barreda and the community of Lirima for granting access to the field and providing logistic help. We thank C. Nievas for providing assistance with SEM imaging. Financial support: Universidad Mayor (OI100780).

References: [1] Rice, M. S., et al. (2010), Icarus, 205, 375-395. [2] Ruff, S. W., et al. (2011), JGR 116, E00F23. [3] Barbieri, R. and Cavalazzi, B. (2014), Challenges, 5, 430-443. [4] GFC Ingenieros (2010). Unpublished report. [5] Nicolau, C., et al. (2014), J. Volc. Geotherm. Res., 282, 60-76. [6] Blard et al., (2011). Quat. Sci. Rev. 30,3973-3989

[a] School of Geology, Universidad Mayor; [b] NASA Ames Research Center & Blue Marble Space Istitute of Science.