Europlanet TA Scientific Report

PROJECT LEADER

Project number: 22-EPN3-026
Name: Pablo L. Finkel
Home Institution: Centro de Astrobiología (CAB), CSIC-INTA
TA Facility visited: TA1.05 Makgadikgadi Salt Pans, Botswana

Project Title: *Life detection and biosignature preservation studies via lipid biomarker analysis in Makgadikgadi Salt Pans, an evaporitic Mars analogue in Botswana.*

Scientific Report Summary.
(plain text, no figures, maximum 250 words, to be included in database and published)

In large evaporitic basins such as the Makgadikgadi Salt Pans in Botswana, a series of strategies that promote the long-term preservation of lipids take place in its immediate subsurface: protective mineral-organics interactions, halite encapsulations within matrices, salt-derived enzymatic inhibition, cellular adaptations, and entombment by chemical precipitation of minerals. These strategies, plus the high preservation potential of lipid biomarkers, crafts a recipe for optimism in regard to the state of the lipids found in Makgadikgadi, whose degradation may be effectively attenuated as their preservation is enhanced.

The main goal of this project was to collect different types of samples from the pans to characterize their lipid biomarker content to **a)** identify biological (molecular and isotopic) features and **b)** to assess lipid preservation and/or degradation. Samples with protective matrices suitable for organics preservation include halite crusts, xero-mineral matrix and silcretes from Sua Pan, as well as silcretes, calcretes and mineral precipitates found in inverted channels from a relict delta. More humid samples where these protective features may lack included surface and subsurface soil samples from concentric layered mounds believed to have formed under a water table. Nonethless, these mounds present a geomorphological analogy to the Equatorial Layered Deposits (ELD) on Mars, and given the infiltrating capillary fringe that render the Makgadikgadi mounds humid, a similar process on Mars could establish the ELDs as habitable refugia. In the laboratory, once the lipid profile of all samples is characterized, we will proceed with irradiation studies to challenge lipid degradation in protective versus non-protective matrices.

Full Scientific Report on the outcome of your TNA visit

The visit to the Makgadikgadi Salt Pans has resulted in a successful field campaign given the targeted extremely dry conditions encountered at the end of the dry season, and based on the retrieved sample types, our scientific report can be divided into two major areas.

1. Sua Pan, Kubu Island surroundings

Sua Pan is the eastern major pan in Makgadikgadi. On its southwestern shore lies Kubu Island, a slightly elevated terrain with rocky features and multiple baobab trees that becomes surrounded by shallow water during the wet season. We have collected samples from different geomorphological features of the pans in the proximities of Kubu Island that may offer distinct niches of protection for lipid biomarkers. In Sua Pan we focused on two features that may offer higher degrees of protection: halite crusts and hydrated silcretes, with potential to preserve organics by lattice encapsulation or mineral entombment, respectively.

Halite crust sampling in Sua Pan involved the collection of wetter crusts adhered to the pan floor forming polygonal patterns indicative of rapid desiccation (Figure 1). Beneath these crusts, wet sediment protected from UV incidence was also collected (Figure 1) to compare the implications of drier/salty conditions versus wetter/less salty conditions in the preservation of lipid biomarkers. Additionally, we collected halite crystals that formed directly under the surface of highly desiccated crusts (Figure 2) that, as opposed to the wetter, adhered crusts, were lifted from the pan floor with no sediment directly beneath them. Interestingly, some of these crystals displayed an orange coloration suggestive of halophilic colonization (Figure 2). Moreover, we collected silcrete duricrusts from the pan floor. These silcretes were directly exposed and were associated with glauconite phyllosilicates, which provides a blue-green colour (Figure 3). Finally, a desiccated microbial mat with visible layers was also collected from the Sua Pan floor (not shown).

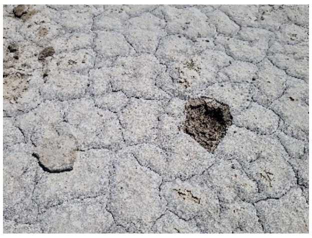


Figure 1. Wet halite crusts.

Figure 2. Halite crystals.

Figure 3. Glauconite silcretes.

On the way to the western Ntwetwe Pan, we also sampled other types of white, amorphous silcrete precipitates (not shown) suggestive of elevated hydration and thus, suitability for biomarker preservation.

2. Concentric layered mounds, Ntwetwe Pan

The motivation to sample the concentric layered mounds in the northwestern region of the Ntwetwe Pan is twofold. First, these layered mounds with low relief share geomorphic similarities with spring mounds from the Equatorial Layered Deposits on Mars, considered to have formed from groundwater upwelling, evaporation and wind deflation, also hypothesized formation processes in Makgadikgadi (Franchi et al., 2020). If such mounds are standing atop an underground water table on Mars, humidity and thus unconsolidated soil will perhaps challenge the preservation of ancient biosignatures, yet at the same time promote a possible habitable subsurface environment where a capillary fringe rises and conveys moisture to the mounds. This links directly with our second motivation: to assess the lipid biomarkers of the surface and subsurface of the mounds to compare hypothesized dry surface versus humid subsurface conditions.

We selected three mound systems along a hypothesized time transect. The first system, supposedly younger, was closer to the western pan shore and was not yet fully isolated from the grassy terrain (1). The second system was a wide, isolated mound (2) easterly aligned with the first one, and the third target was a small mound (3) located further to the east and assumed to be older than the first two (Figure 4).

Figure 4. Three selected concentric layered mounds for sampling.

Each of the selected mounds was sampled in three different spots (Figure 5), as all three mounds shared similarities in their layered structure. The first spot (1) was always an elevated terrain in the west side of the mound, generally with abundant grass in all three mounds (Figure 6). The second spot (2) was the white, thick layer that can be seen in most mounds when observing from satellite view (Figure 5). This spot was distinguishable from the ground as it seemed to always be the highest point of the mound. The third spot (3) was the western interface between the mound and the pan, and also its lowest point.

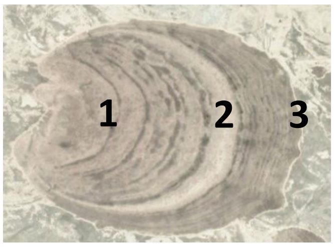


Figure 5. Sampling spots.

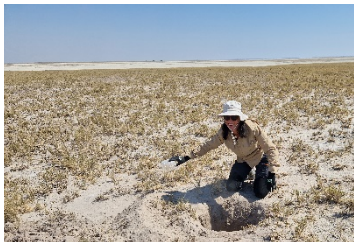


Figure 6. Laura in spot 1 (mound 2).

At each of the spots (in all three mounds) we dug a ~65 cm deep ~50 cm wide hole (Figure 7) from which we took a surface (named TOP) and a subsurface (named BOTTOM) sample of soil (Figure 8). The subsurface sample was always taken at the deepest point (~65 cm). In every hole, the surface soil was always drier than the bottom, however, sharp differences in humidity were only observed in the interface between every mound and the pan (spot 3 in all mounds), as shown in Figure 9.

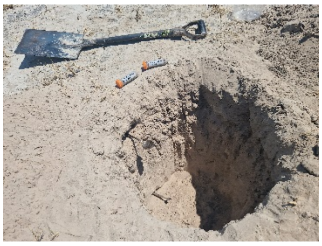


Figure 7. Hole dug in the mound.

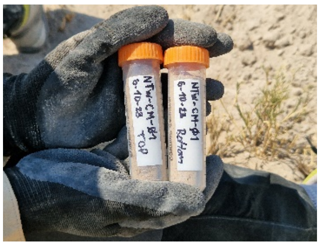


Figure 8. TOP and BOTTOM samples.

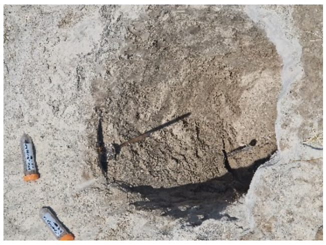


Figure 9. Hole with humid subsurface.

In the future, mound samples, expected to offer poor protection for biomarker preservation, will be artificially irradiated along with the halite crusts, minerals from the inverted channels, calcretes and silcretes, which are otherwise expected to offer a higher degree of protection. Such experiments will help us gain insights as of which Martian sites are more likely to host any potential geolipids.

- Give details of any publications arising/planned (include conference abstracts etc.)

Depending on the obtained results, we will try to publish 1-2 scientific stories out of the set of samples we collected from Sua and Ntwetwe pans, around the following points:

- Molecular and isotopic fingerprints of life in different scenarios/matrices on the Makgadikgadi salt pans (halite crusts, desiccated sediments, mineral precipitates, desiccated microbial mats, etc.).
- Preservation patterns (seasonal desiccation, long-term halite encapsulation, xeropreservation, organo-mineral protection, etc.).
- Molecular and/or isotopic shifts with time on the lipid biomarkers profile in the concentric layered mounds.

Depending on the significance of the obtained results, we will target high impact journals such as PNAS, Astrobiology, Science of the Total Environment, or Frontiers in Microbiology.

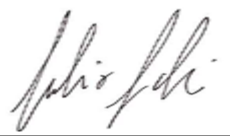
Preliminary results will be presented in international conferences and meetings such as Lunar and Planetary Science Conference, European Astrobiology Network Association, or Europlanet Science Conference.

- Host confirmation

Please can hosts fill in/check this table confirming the breakdown of time for this TA project:

Dates for travel to accommodation for TA visit (if physical visit by applicant)	Start Date of TA project at facility	Number of lab/field days spent on TA Visit pre-analytical preparation	Number of days in lab/field site for TA Visit	Number of days spent in lab for TA Visit data analysis	End Date of TA project at facility	Dates for travel home (if physical visit by applicant)
Departed: **01-10-23** Arrived: **02-10-23**	**02-10-23**	**1 day** **02-10-23**	**6 days** **03-10-23-08-10-23**	**1 day** **09-10-23-**	**09-10-23**	Departed: **11-10-23** Arrived: **12-10-23**

The host is required to approve the report agreeing it is an accurate account of the research performed.

Host Name	**Fulvio Franchi**
Host Signature	
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- Project Leader confirmation

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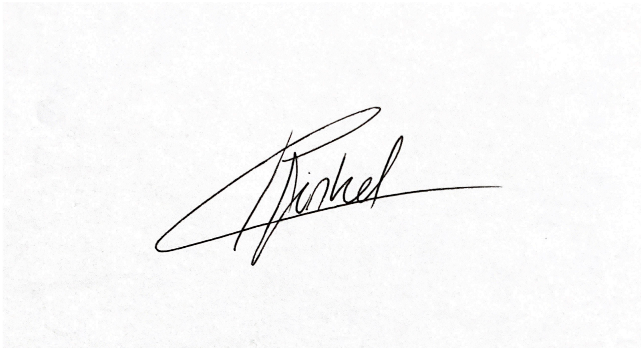
Project Leader Signature	
Date	**16/10/2023**