MICROBIAL BIOSIGNATURE INVESTIGATION IN AEOLIAN ENVIRONMENT USING µXRF (X-RAY FLUORESCENCE) ANALYSES THAT SIMULATE THE PIXL INSTRUMENT ONBOARD THE PERSEVERANCE ROVER FROM NASA'S MARS2020 MISSION. M. Nachon[1], R.C. Ewing[1], M.M. Tice[1], B. Williford[2]. [1]Department of Geology & Geophysics – Texas A&M University (mnachon@tamu.edu), [2]SRL – Texas A&M University.

Introduction: Looking for evidence of ancient life on Mars using the "Perseverance" rover is the key objective of NASA's Mars 2020 mission **[1]**. Onboard the rover, the PIXL (Planetary Instrument for X-ray Lithochemistry) instrument will enable the acquisition of µXRF (X-ray fluorescence) analyses, coupled to high-resolution images, to examine fine-scale chemical variations of Mars samples **[2,3]**.

Here we perform PIXL-like analyses to investigate biosignatures of microbial mats present in a modern wet aeolian environment. Microbial mats are some of the oldest known ecosystems and form in a wide range of environments. Among clastic depositional environments, lacustrine and deltaic sedimentary systems are typically considered as targets of high biosignature hosting and preservation potential **[**e.g. **4]**. However, less is known about the presence and detection of biosignatures in aeolian environments, and how such biosignatures might be detected using the Perseverance payload, if present on Mars.

Methodology and Data:

Field work and sample collection were performed in the wet aeolian system of Padre Island National Seashore (Texas), where microbial mats develop on wind tidal flats and get buried in aeolian deposits (Fig. 1A,B). To expose this stratigraphy, we dug trenches and we collected sediment peels using epoxy applied to a mesh and a paper backing to preserve sedimentary structures (Fig. 1C).

Laboratory µXRF analyses were performed with a benchtop Horiba XGT7000 (Texas A&M University) operated with a 100 µm probe head. Samples were scanned to collect XRF compositional maps (Fig. 1) at 100 µm/pixel.

Interactive interface for µXRF data: A web-based tool was designed to simulate PIXL analyses from the µXRF laboratory data. This application enables down-sampling of portions of the XRF maps to simulate sampling configurations of pre-determined PIXL measurements ("templates"), e.g. measurement spot spacing, length and number of rows and columns.

Participative survey: A survey was designed to study how different investigators might select PIXL measurements to investigate a biosignature-bearing outcrop.

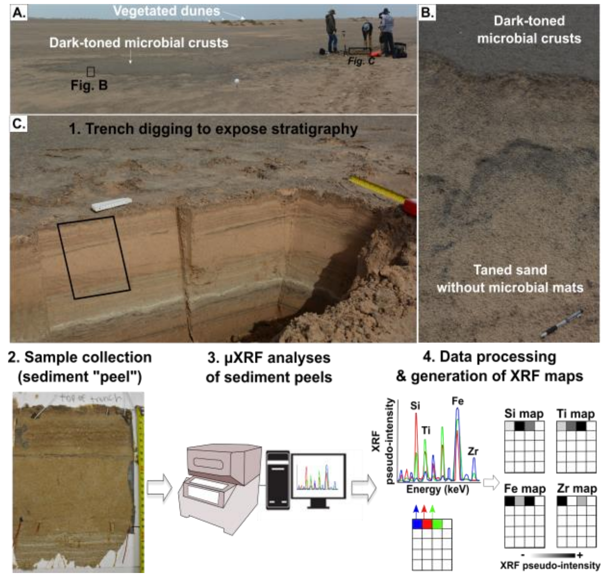

Figure 1: Methodology pipeline from field work and samples collection of microbial mats & crusts in the aeolian sediments of Padre Island National Seashore to laboratory µXRF analyses.

Results:

Microbial biosignature: Surfaces with microbial mats are characterized by high concentrations of dark-toned heavy-mineral grains (e.g. ilmenite, magnetite, rutile, zircon) compared to surrounding loose sediments without mats **[5,6]** (Fig. 1). We interpret this to be the result of prolonged sorting during sediment transport across these surfaces compared with minimal sorting during rapid burial or exhumation on non-stabilized sediment **[6,7]**. This differential sorting is reflected in elevated Ti, Fe, and Zr concentrations in mat-bearing layers compared with surrounding sand. Upon burial, the horizons bearing microbial mats acquire a signature in Ti and Fe distinct from that of other aeolian horizons: iron oxides tend to get reduced in the subsurface during mat decomposition, resulting in lower Fe/Ti ratios **[6,7]**. In the exposed stratigraphy (Fig. 2), the horizons inferred to be buried microbial crust/mats appear as crinkly and disrupted laminations rich in heavy-minerals (Fig. 2B).

PIXL-like µXRF analyses: We collected large maps on a selection of abiotic and biotic horizons, including buried microbial mats, aeolian ripple lags, and aeolian cross-bedding (Fig. 2A,B).

We investigated each horizon with two types of PIXL-like templates: three contiguous 20-mm-long line scans spaced by 2 mm (Fig. 2C) and 74 mm^2 square scans (Fig. 2D); these types of maps would be subject to significantly different mission constraints in timing and rover resources. We investigate the morphological and chemical properties of these horizons, to determine which aspects of the microbial biosignature can be determined with each of these PIXL-like µXRF analyses.

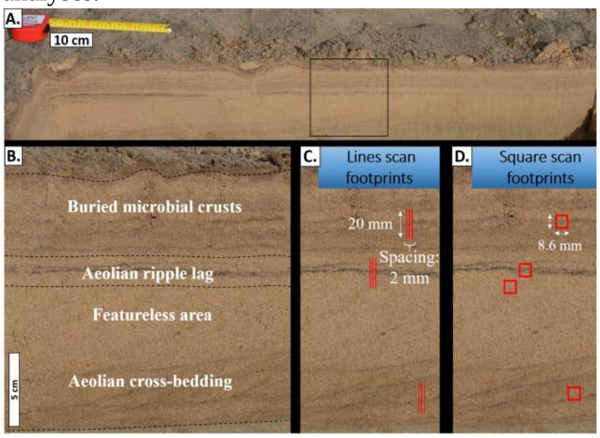

*Figure 2: **A**,**B:** Stratigraphy of buried microbial crusts and aeolian features. **C**,**D**: red footprints of 2 types of PIXL measurements (line scan, square scan).*

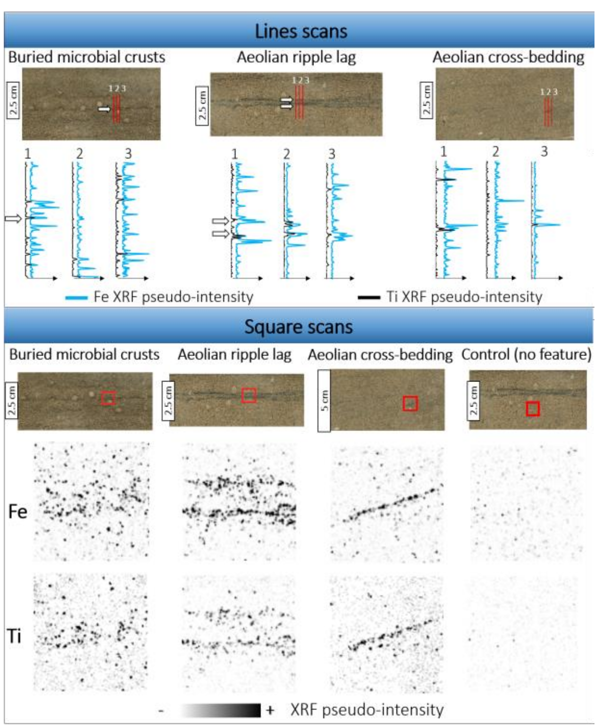

Figure 3: Corresponding µXRF analyses of the horizons targeted in Fig. 2.

In particular, buried microbial mats appear well characterized in square scans: the highest Fe, Ti and Zr intensities are detected along the disrupted laminations (Fig. 3), consistent with concentration of associated heavy minerals in surface mats. This signature is less visible in the line scans, where Fe and Ti co-occurrence is less obviously associated with the laminations.

This is likely due to the very thin diameter of the 100 µm XRF analysis footprint relative to the lateral variability of the discontinuous laminations (Fig. 4). Thus, here the lines scan was not sufficient for clearly determining one of the key compositional aspects of the biosignature. Only the square scan measurement allowed for a clear visualization of the Fe and Ti-rich signature.

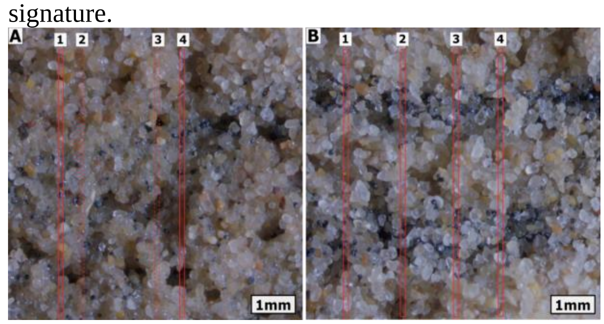

*Figure 4: Microscope images of buried microbial crusts (**A**) and aeolian ripple lag (**B**) and footprints of PIXL-like line scans (red rectangles).*

Our pipeline offers the opportunity to investigate the influence of key parameters on the analysis of biosignature-bearing outcrops via PIXL. Such studies enable determining the criterions that would streamline biosignature detection and identification by the PIXL Team **[8]**. It also allows investigating optimal number, size, and distribution of PIXL analyses in order to assess biosignature identification. This is key, given unprecedented efficiency required to achieving the Mars 2020 mission objectives.

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References: **[1]** Farley et al., Mars 2020 Mission Overview (2020) *Space Sci Rev*. **[2]** Allwood et al., PIXL: Planetary instrument for X-ray lithochemistry. (2020) *Space Sci. Rev*. **[3]** Allwood et al., LPSC (2021). **[4]** Hays et al., Biosignature preservation & detection in Mars analog environments (2017) *Astrobiology*. **[5]** Ewing et al., Distribution of mat biosignatures in a wet aeolian system, ICAR abstract (2018). **[6]** Tice et al., 318-205 Heavy mineral signatures of processes in microbial mats and crusts, AbSciCon (2019). **[7]** Tice et al., Microbial Communities from wet windy environments on the modern & ancient Earth, AbSciCon (2019). **[8]** Nachon et al., Protocol for biosignature identification in wet aeolian deposits, Abstract #2740 LPSC (2020).