MAPPING MINERALOGY AND IN SITU OBSERVATIONS IN ACIDIC SALINE LAKES IN WESTERN AUSTRALIA. T. A. Plattner[1], B. E. Schmidt[2], A. Baldridge[3], J. M. Weber[4], M. A. Birmingham[5], P. Doran[6], E. Ingall[1], J. Wray[1], F. Rivera-Hernandez[1], J. S. Bowman[7], S. Som[8], A. Schartup[7], S. Buessecker[9], E. Quartini[2], L. Fisher[7], E. R. Paris[9], B. Klempay[7], M. M. Weng[10], C. Sephus[7], C. Pozarycki[1], A. Odenheimer[11], the Esperance Tjaltjraak Native Title Aboriginal Corporation[12], M. Towner[13], and the OAST Team. [1]School of Earth and Atmospheric Sciences, Georgia Institute of Technology, Atlanta, GA (tplattner24@gatech.edu). [2]Department of Earth and Atmospheric Sciences, Cornell University (britneys@cornell.edu). [3]Saint Mary's College of California. [4]NASA Jet Propulsion Lab, California Institute of Technology. [5]University of Kansas. [6]Louisiana State University. [7]University of California, San Diego. [8]Blue Marble Space Institute of Science. [9]Stanford University. [10]Georgetown University. [11]University of California, Los Angeles. [12]Esperance, WA, Australia. [13]Curtin University, Perth, WA, Australia.

Introduction: Since only records of past liquid environments can be studied on Mars, analog environments on Earth such as the Western Australia Transient Lakes (WATL) present an opportunity to investigate what early lacustrine Martian environments could have been like and understand how once active lake systems leave a record of their presence behind. The WATL are located in the Archean Yilgarn Craton of Western Australia, which is host to hundreds of saline lakes [1-3]. The WATL change over time, fluctuating in depth due to varying wet/dry stages from the influx of groundwater and rainwater [1-3]. As these cycles occur, properties related to habitability and organic compound stability such as ionic composition, pH, salinity, and water activity can vary, influencing salt precipitation and biomarker preservation. The abundance of evaporative minerals such as halite and gypsum in the WATL and salt crusts along the WATL shorelines could provide a remotely observable indication of the environmental cycling and preservation potential.

The Yilgarn Craton is unlike any other area on Earth due to its exceptional geological stability, and the fact that this region has undergone an extensive shift in palaeomagnetic latitude during the last 500 million years, resulting in climatic extremes ranging from humid to arid, which led to varied and intense weathering of bedrock and valley fill [4]. Thus, these lake environments have been going through wet/dry cycles for millions of years and they continue to go through these cycles to the present day [4]. As a result of these cyclic patterns, salinization occurred in the Yilgarn Craton from as long ago as 2.8 Ma, concentrating in valley floors as dry and wet cycles prevailed throughout its history. Furthermore, ongoing weathering throughout this time influenced the regolith, water chemistry, and the accumulation of massive volumes of salt in the Yilgarn Craton [4]. These conditions make the lakes an analog for multiple habitable environments predicted to have existed and evolved during the Noachian and Hesperian Eras on Mars, and could help us understand how similar environments on Mars transitioned from wet to dry.

Objective: To choose from the hundreds of shallow lakes within the Yilgarn Craton, we down selected lakes of interest using band indices [5] and were able to narrow down our list of 80 lakes to roughly 40 lakes for our 2022 field campaign to the WATL. During our fieldwork, we sampled 40 lakes and obtained in situ data of each lake environment with our suite of instruments similar to what is on many Mars rover missions: a portable spectrometer, LIBS, XRF, and Raman instruments. My objective was to collect primarily gypsum and halite samples, and any other mineral assemblages present, from the lake and surrounding shoreline and analyze the samples in situ with our suite of instruments. In addition, we used spectral data from the Operational Land Imager (OLI) on the Landsat 8 & 9 spacecrafts to determine what type of evaporative minerals the lakes contain and what wet/dry stages they were in during the time of our fieldwork, and over the last year.

Methods: To map these wet/dry stages over time in various lacustrine environments, we obtained Landsat 8 & 9 Collection 2 level-2 data from USGS. Using this data, we utilized Radwin and Bowen's 2021 method for identifying halite and gypsum with the use of band indices [6] to map the mineralogy in the WATL.

Band Indices and Classification Images: After preprocessing the data, band indices [6] for gypsum and halite were completed, and an RGB image of those band indices and a classification image was produced to map the evaporites in each lake environment. The following band math indices were used to map halite and gypsum with Landsat 8 & 9 Collection 2 level-2 data:

- Halite: (Band 4 – Band 6)/(Band 4 + Band 6)
- Gypsum: (Band 6 – Band 7).

In situ and Lab-based Analyses: Multiple samples were taken to capture the variation within each lake environment and the samples were recorded at each site through triplicate sample collection with each instrument. To mimic planetary missions to Mars we also adapted a similar approach to how we collected data. For example, we made sure to do the nondestructive sample techniques first (i.e., VNIR spectrometer, XRF, and Raman) and then completed sample collection with the more destructive sample techniques (i.e., LIBS) second. These analyses will help give a more precise measurement of gypsum and halite, and identify other mineralogical features (i.e., diagenetic veins or extremely weathered rock that were present in some of our field sites) that biomarkers may be associated with. Thus, it is important we connect these in situ features to the remote sensing to inform where the best places are in these environments for potential biomarkers to be preserved, and then extrapolate lessons learned to the history of environments on Mars.

Results: From the analysis, various images (*Figure 1*) were produced for different months spanning the last year, including the time of our fieldwork in August 2022. Here we focus on the Landsat 9 image taken on January 3rd, 2022 of our F21 field site to show our methods clearly, since during our fieldwork the lakes were flooded and very little evaporites were seen along the shoreline. For each image acquired, a true color image was produced along with monochromatic images of our band indices, an RGB image (*Figure 1 - top*), and a classification image (*Figure 1 - bottom*). were also produced. From these distinct images we estimated the distribution of gypsum and halite surrounding the lakes. Additionally, by comparing different months in a calendar year we characterized the seasonal variability in gypsum and halite, along with mapping how the water dried up over time during these wet/dry cycles. From the remote sensing, there is notably more halite and gypsum overall in the WATL during December - February relative to other months. consistent with undergoing a seasonal dry cycle at this time. We observe increased abundance of evaporate minerals visible near their shores during local summer.

Furthermore, remote detection of mixtures of halite and gypsum within our field site, agrees with the field spectroscopy recorded at this lake environment with handheld sensors. Figure 1 shows the salt mixture in yellow, and resolves variability in the surrounding geologic units, where sand and weathered rock are shown in cyan and orange that were confirmed in situ during our field campaign. These preliminary results suggest that spectral unmixing and further pixel-scale and spatial investigation may be fruitful for representing accurately what is present in these locations (e.g. diagenetic veins and clay minerals). Thus, in an environment such as our F21 field site, we can use a combination of in situ and remote sensing to connect the geochemistry, extremely weathered minerals, and evaporites to describe what is happening in the lakes as they continually go through wetting and drying cycles.

Future Work: Further verification of our samples will be completed and comparisons on how different the spectra look in situ vs in the lab, and how they compare to the remote sensing data will also be completed. We plan on continuing to map the minerology in these environments through the method [6] presented here for all the field sites that we visited. Lastly, we will extend the environmental characterization surrounding the salt pan in Figure 1 to disentangle the signals from large outcroppings of weathered rock and windblown salt from the lake, resulting in a spectrum from that area that is a mixture of various minerals.

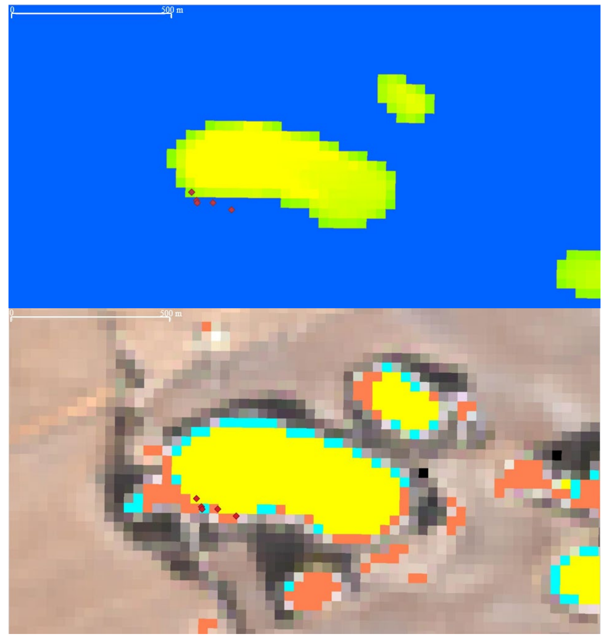

Figure 1: (Top image) This is an RGB image of the halite and gypsum band indices for our F21 field site, where R = halite, G = gypsum, and B = surrounding terrain that was masked. (Bottom image) This is a classification image of our F21 field site, where yellow = salt pan, orange and cyan = mixture of sand and weathered rock. This image was taken on January 3rd, 2022 and the Landsat reference number is LC09_L2SP_109083_20220103_20220122_02_T1.

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