SPECTRAL INVESTIGATION OF THE MAKGADIKGADI SALT PANS AS A PLANETARY ANALOG FOR ANCIENT FLUVIO_LACUSTRINE ENVIRONMENTS ON MARS.

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Introduction: Spectrometers working in the visible-near infrared (VNIR) wavelength range are extremely useful to identify the surface composition of Mars and other planetary surfaces. However, in order to understand the formation of the detected mineralogy, the interpretation of these data requires the study of Earth analogs. The Makgadikgadi Salt Pans in northern Botswana [1] offer a unique opportunity to study the mineralogy of evaporites and clays derived from fluvio-lacustrine sediments in their geological context. We present here first result of a field research done in August 2022.

Geologic Settings: The Makgadikgadi Salt Pans are located in Northern Botswana and cover an area of about 16,000 km^2. They are located in the basin of the Paleo-lake Makgadikgadi, that covers the entire region, i.e., up to an area of about 80,000 km^2. During the rainy season, if precipitation is abundant, the pans are filled with water. During the dry season, from May to October, an expanse of salt deposits dried in the sun above a layer of clay and sand. The pans are completely flat. However, locally, some exposed rocks such as granite, dolerite, etc. exist.

During the duration of nine days, 22 sites were chosen for detailed measurements (Fig. 1) in order to 1) obtain a horizontal profile of the mineralogical diversity throughout the Pans from the topographic center to the shoreline; and (2) investigate variations in the mineralogical composition of the evaporites and clays due to the influence of outcropping (bedrock) units.

Instrument and methods: The spectral measurements were performed directly in the field with our portable visible/near-infrared spectrometer (PSR +3500; Spectral Evolution) that samples the surface between 0.35 and 2.5µm. Due to a FOV 3 × 3 mm, the instrument can be easily applied to drilled cores. This spectral range of the PSR +3500 matches that of several instruments' onboard past, present and future Mars missions (Mars Express, MRO, Mars2020, Exomars).

Spectral Properties: Depending on the local variety of deposits including different surface layers, each spot can include several sub-sites in order to characterize the transition in spectral properties between the deposits (Fig. 2). The measurement sites also include parts of the pans with still wet deposits due to recent unexpected rain (Fig. 2b).

Spectra reveal that salts such as trona, halite, mirabilite dominate the more or less fresh, white to light brown, several mm thick uppermost crusts throughout the pans. They are most prominent, where the salts themselves or at least the clays underneath this layer are still wet. The special shape of the water-related feature at 2µm implies that sodium hydrogen carbonates such as trona is the spectrally most dominant compound of the salt layer (Fig. 3). In the wettest location, a thin greenish layer of organic material has been found which causes a characteristic feature near 0.7 µm. In regions that have been dry for a prolonged period, clays such as montmorillonite (Fig. 3) dominate over salts. A more detailed spectral analysis is required to solve the mineralogy of these deposits based on their absorptions in the spectral region between 2 – 2.5 µm. Rocky outcrops (silcrete) within the pan [2] often show a distinct greenish color. Although, these outcrops consist mainly of silica, the spectra of these rocks also show glauconite (sometimes in combination with illite; Fig. 3), which is responsible of their characteristic green color. Glauconite possibly develops as a consequence of alteration of sedimentary deposits commonly associated with low-oxygen conditions. Intriguingly, glauconite just recently has been identified also to exist in Gale crater on Mars [3].

Outlook: The collected spectra show a large variety of minerals characteristic for lacustrine environments. In combination with the knowledge of their geologic context the data will be extremely useful for identifying and mapping similar environments on Mars by spectrometers such as Mars Express OMEGA and MRO CRISM etc. with potential for future landing sites. The ongoing work will continue with the analysis of samples collected for each investigated spot to evaluate the field measurements. In addition, we analyze satellite data to be able to tie the field data also to remote sensing data as we would do in planetary science in order to discuss the identified mineralogy with information about the recent and past climate conditions.

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References: [1] Burrough, S. L. (2022) in "*Landscapes and landforms of Botswana*", 77-90, Eckardt, F. D., Springer. [2] Nash et al. (2022) in "*Landscapes and landforms of Botswana*", 223-246, Eckardt, F. D., Springer. [3] Losa-Adams et al. (2021), 5, 936–942.

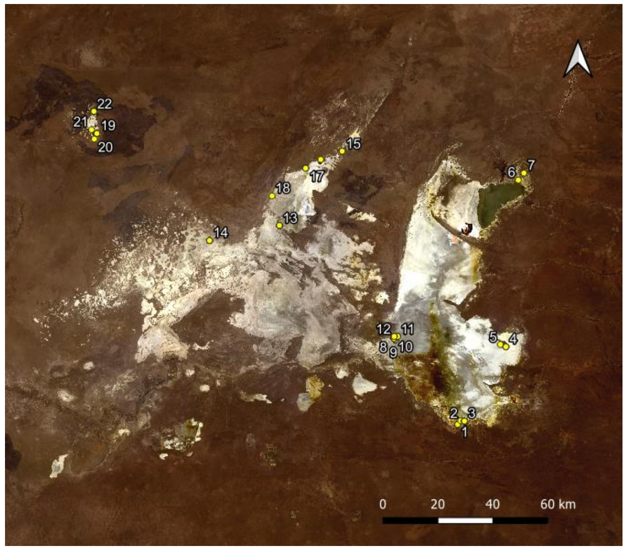

Fig. 1: Landsat 9 color composite with images acquired in August 2022 showing the measurement spots.

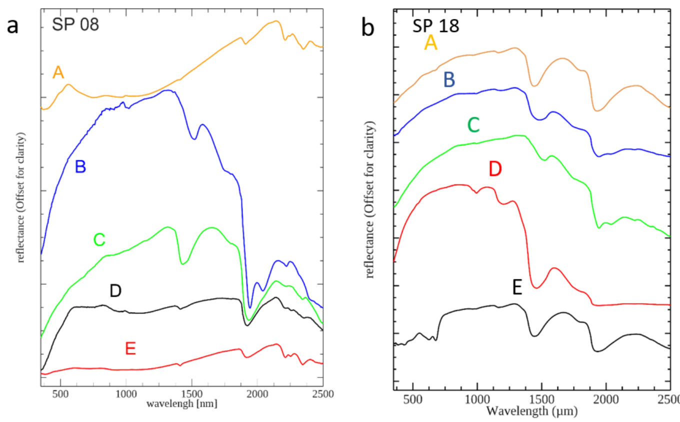

Fig. 2: Examples of spectra of the surface units acquired at a) Spot 8: A – granitic rock, B – pegmatite dike, C – whitish crust next to granite, D – salty white crust, E – greenish bedrock, and b) at Spot 18: A – Brown soil between salt crust, B – light brown portion of the salt crust, C – white coating, D – white crust, E – green organic material.

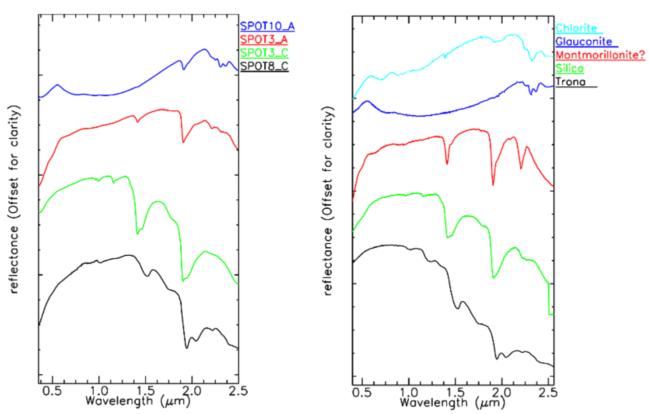

Fig. 3: Comparison of example field spectra (left) with laboratory spectra of the USGS spectral library (right).