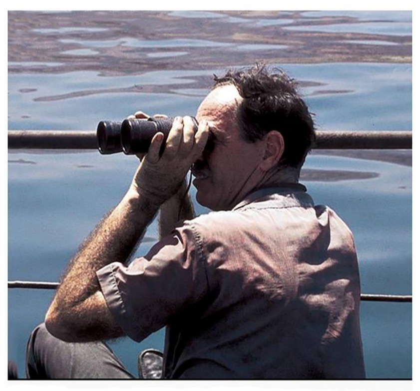

Neev Center for Geoinfomatics

Dead Sea Stromatolite Reefs: Hyperspectral Remote Sensing and the Search for Life in Extreme Environments

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Abstract

The Dead Sea is one of the most saline lakes on Earth, and only few organisms manage to survive in this environment. However, at some locations of the current Dead Sea shore active and diverse microbial communities flourish. In the geological past, similar microbial-rich environments left their marks under the form of stromatolites. Stromatolites are now thoroughly investigated to understand the appearance of life on Earth and potentially on other planets. I am examining fossil stromatolites in order to create a spectral classification for detection of their structures through spectral measurements, and will examine the possibility to upscale the mapping using airborne and satellite imagery. This study will evaluate point spectroscopy and remote sensing technologies in order to classify stromatolite fossils in a selected study site near the Dead Sea.

Fig.1 Stromatolites dome at the Dead Sea

Fig.2 A rich microbial pond at the Dead Sea shoreline

The Research aims

- Evaluate satellite remote sensing (RS) and field spectroscopy for characterizing stromatolites.
- Examine the relationship between spectral and XRF observations for a precise detection of stromatolites.
- Upscaling field spectral observations to aerial/satellite RS images.

Fig.3

Fig.4

Methods

- Spectral analysis: Spectral characterization of stromatolites using a spectrometer (FieldSpec 4 with 2150 spectral bands in the 350-2500 nm range) and XRF.
- Detection and mapping of the stromatolites via hyperspectral satellite and airborne imagery.
- Image analysis using ENVI software's classification tools.
- Spectrum data analysis using the gradient-boosting algorithm of the Scikit-Learn module in order to identify the most indicative wavelengths for distinguishing the targeted layers.

Results

Fig.5 Hyperspectra ratio line

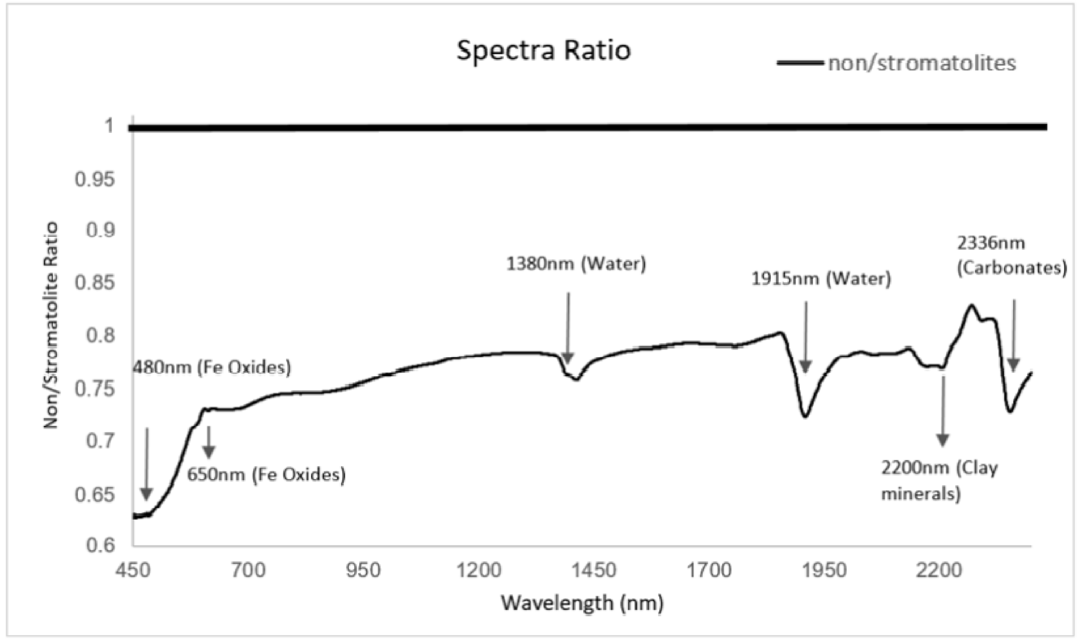
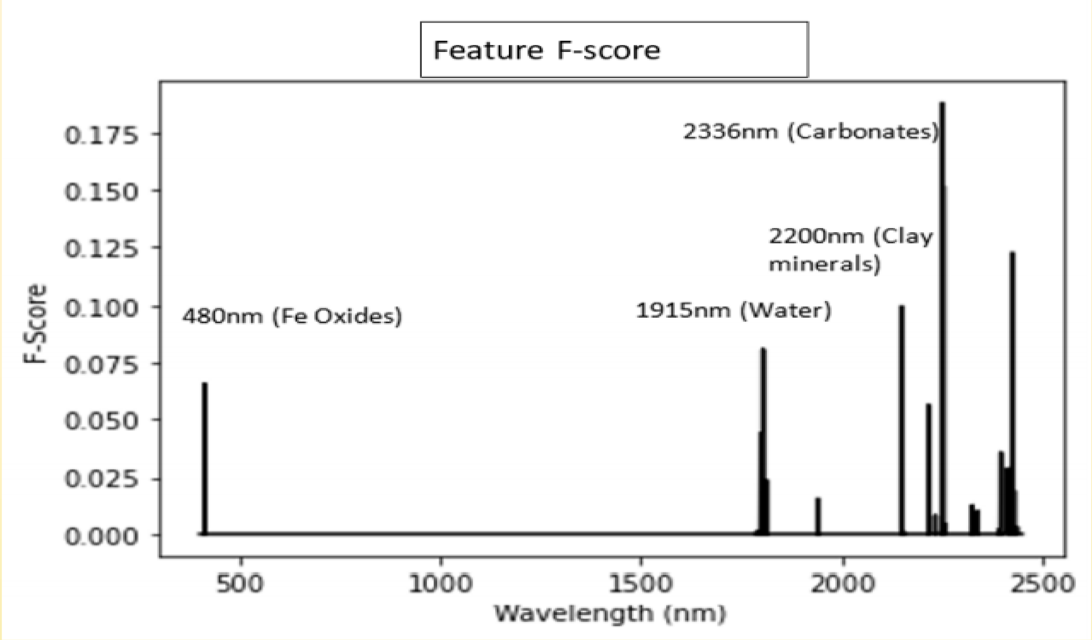
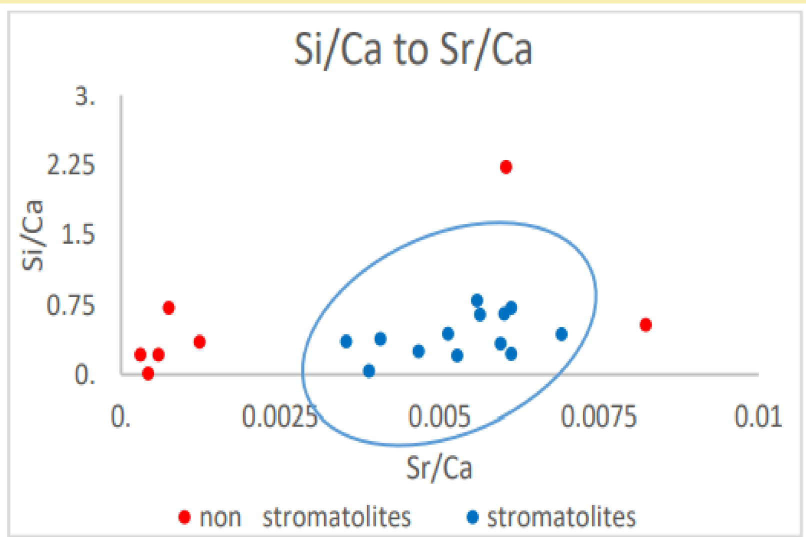


Fig.6 Machine Learning model



In order to evaluate the differences between the two groups, I have divided the average hyperspectra of the background by that of the target (Fig.5). The absorption of principal constituents is shown in Fig.5 and Fig.6 , from Rossel and Behrens's work (2010)*. The gradient-boosting algorithm identified, with 100% success, the stromatolites from the background by using the most indicative wavelengths. The model is using wavelengths of "atmospheric windows"; the most indicative wavelengths were found around 2336 nm, which indicates the calcite absorption wavelength, and around the clay minerals absorption at 2200 nm. The correspondence between the spectral ratio and the machine learning model enhances the overall capability of the model to predict the differences between the target and the background (Fig.6).

Fig.7 XRF's readings



In attempt to find a clear differentiation, the ratio Sr/Ca was found promising. The suggested explanation is that stromatolites likely to contain a high aragonite concentration as compering to their environment. Strontium, with its large cation, replaces calcium preferentially in aragonite minerals, (silicon represents detritus) (Fig.7).

Conclusions

The most indicative wavelengths for distinguishing stromatolites, were found in the SWIR2 spectral range (1800-2500 nm). I will pursue detection of stromatolites using various classification methods on satellite and airborne imagery, using the most indicative wavelengths.

Future work

- Enlarging the sample size up to ~100 target and background specimens.
- Further spectral measurements for the LWIR spectral region, will be acquired with the Telops Hyper-cam, covering the 8.0-11.7 mm region with 122 bands.

acknowledgements

We thank Camille Thomas and Daniel Ariztegui for useful discussions regarding Dead Sea living analogs (Thomas et al., 2021)**

references

*Rossel, R. V., & Behrens, T. (2010). Using data mining to model and interpret soil diffuse reflectance spectra. Geoderma, 158(1-2), 46-54.
**Thomas, C., Vogel, H., and Ariztegui, D.: Unlocking the power of lake multiproxy analyses by understanding subsurface biosphere processes, EGU General Assembly 2021, online, 19–30 Apr 2021, EGU21-8379, https://doi.org/10.5194/egusphere-egu21-8379, 2021.