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Project Report

An orbital and in-situ analysis of Lake Salda microbialites as a modern analog for Jezero crater, Mars

Overview:

I conducted this fieldwork in August 2019 to investigate Lake Salda in southwestern Turkey as a modern analog for Jezero crater on Mars, the selected landing site of the Mars 2020 rover. I was joined by my advisor Dr. Briony Horgan (Purdue University) and our colleagues Dr. Nurgul Bacli and Yagmur Gunes (Istanbul Technical University). During our 4-day field campaign, we categorized in detail the morphologies and textures of detrital and lacustrine deposits around the lake perimeter. In addition, we collected 80+ rock and sediment samples from representative deposits around the lake (microbialites, muds, deltaic sediment, beach sediment, etc.), 6 sediment cores along the shoreline, as well as bedrock in the surrounding watershed (serpentinized ophiolites, limestone, etc.). Observations and samples collected during this field project will aid on-going and future work aimed at constraining the origin and astrobiological potential of carbonate-bearing deposits in Jezero crater, and developing methods for detecting potential biosignatures with Mars 2020 instrumentation.

Background and Motivation:

The search for potential signs of ancient life on Mars is one of the priority goals defined by the NASA Science Mission Directorate in the 2018 Strategic Plan. In a major step toward this goal, the Mars 2020 rover will investigate an ancient lacustrine environment at Jezero crater to search for signs of life, or biosignatures, and cache samples for future return to Earth. Hydrated Mg-carbonate-bearing deposits have been detected from orbit throughout Jezero, some of which may be related to past lake activity. Carbonates precipitated within lacustrine systems on Earth have high morphological, organic, and isotopic biosignature preservation potential and can be biologically mediated. Thus, the Mg-carbonate bearing deposits in Jezero may also have high biosignature preservation potential and will be high priority targets for the Mars 2020 rover. However, our ability to identify and characterize facies with high biosignature preservation potential in a microbially-dominated, mafic, and alkaline lacustrine system that has been hypothesized for the Jezero paleolake is limited due to the rarity of these types of systems on Earth today and in the geologic record. In this study, I aim to better constrain the origin and biosignature preservation potential of the carbonate-bearing deposits in Jezero and refine biosignature search strategies for the Mars 2020 rover, in order to maximize the scientific return of the mission.

Lake Salda (37.55°N, 29.68°E) in SW Turkey is a unique analog for the Jezero paleolake and watershed. It is a deep (~196 m), relatively large (7 km diameter), and alkaline (pH>9) closed basin lake, surrounded primarily by altered ultramafic lithologies (mainly serpentinized ophiolite), with both detrital sedimentation in deltas and authigenic carbonate precipitation (Fig. 1). It is one of the only environments on Earth where hydrous Mg-carbonates (e.g., hydromagnesite) are the dominant precipitates, due to high Mg/Ca ratios from the dissolution of Mg-rich bedrock and alluvial sediment. Microbialites occur in shallow near shore environments and as large subaerial islands. Exposed hydromagnesite terraces occasionally preserve microbialite textures that are several hundred years old. While previous studies have focused on the geochemistry, limnology, and microbial diversity of Lake Salda, our understanding of biosignature distribution and preservation remains limited. Jezero crater is also surrounded by altered and Mg-rich ultramafic terrains, contains hydrated Mg-carbonate bearing deposits, and has experienced fluvial input into a deep (up to several 100 m) and large (45 km diameter) lake basin making Lake Salda a high fidelity modern compositional and process analog for a Jezero paleolake. While we cannot use this site to investigate the effects of long-term exposure, burial, and diagenesis on ancient deposits, Lake Salda will help inform fluvial and lacustrine processes in a Jezero paleolake, the origin of carbonate deposits and their biosignature preservation potential, facies the rover may encounter, and early preservational processes that can help identify taphonomic biases.

Timeline:

Day 1: August 21st, 2019

The first day of the field work was focused on sampling ultramafic bedrock from the watershed. We primarily focused on the SSW side of the lake, sampling a number of bedrock exposures upstream of a dried alluvial fan delta channel (Fig. 2). We also investigated deposits closer to the shoreline, sampling dark-toned detrital sediments as well as light-toned hydromagnesite beach sediments. Our first core sample was collected along the shoreline by hammering a 60 cm long PVC pipe (1-inch diameter) into the beach sediment to investigate the deposits at depth (Fig. 3).

Day 2: August 22nd, 2019

We began the day by investigating a nice exposure of a fluvial delta deposit upstream of the Salda River input on the SW side of the lake (Fig. 4). We sampled various layers within the deposit, including light-toned sands and darker-toned gravels. Next, we surveyed and sampled the Kocaadalar Burnu peninsula, a large carbonate deposit dominated by hydromagnesite muds, sands, and pebbles. Here, modern microbialites are accreting subaqueously in the near shore environment, while older emerged microbialites occur as large subaerial islands ~150-200 m from the shoreline. Terraces occur along the eastern side of the peninsula and are characterized by steep exposures of cemented hydromagnesite muds and sands, and occasionally preserve microbialite textures (Fig. 5). Groundwater springs are present on the peninsula, supplying the lake with Mg-rich waters. In the afternoon, we surveyed another exposure of a fluvial deposit near the Yeşilova delta on the SSE side of the lake, as well as beach/deltaic sediment along the shoreline.

Day 3: August 23rd, 2019

We completed surveying and sampling the lake perimeter, beginning the day investigating the terrace deposits along the eastern shoreline. Here, steep exposures (10-15 m high) of hydromagnesite terraces lie adjacent to a sandy shoreline, with subaqueous microbialites that display pitted textures with poor laminations (Fig. 6). Other sampling locations included a groundwater spring on the NE side, the northern alluvial fan delta, and beach sediment along the western shore (Fig. 7).

Day 4: August 24th, 2019

Our final day of fieldwork was spent revisiting and sampling locations of interest on the SSW side of the lake, including the distal end of an alluvial delta with buried ultramafic cobbles encrusted with hydromagnesite.

Future Work:

Samples collected during this field work will be investigated using detailed mineralogical and biosignature analyzes. Visible and near-infrared spectroscopy (VNIR), X-ray diffraction (XRD), as well as light and electron microscopy (SEM/EDS) will be used to determine source bedrock mineralogy as well as the mineralogy, distribution, and sedimentological properties of fluviolacustrine facies at Lake Salda. I will compare the results to published morphological and mineralogical data from Jezero crater. Morphological, mineralogical, chemical, organic, and isotopic biosignatures in the samples will be investigated using light and electron microscopy, Raman spectroscopy, as well as bulk light stable isotope and organic geochemical analyzes. These observations will help us determine which deposits in Jezero may have the highest potential of preserving biosignatures detectable by the rover.

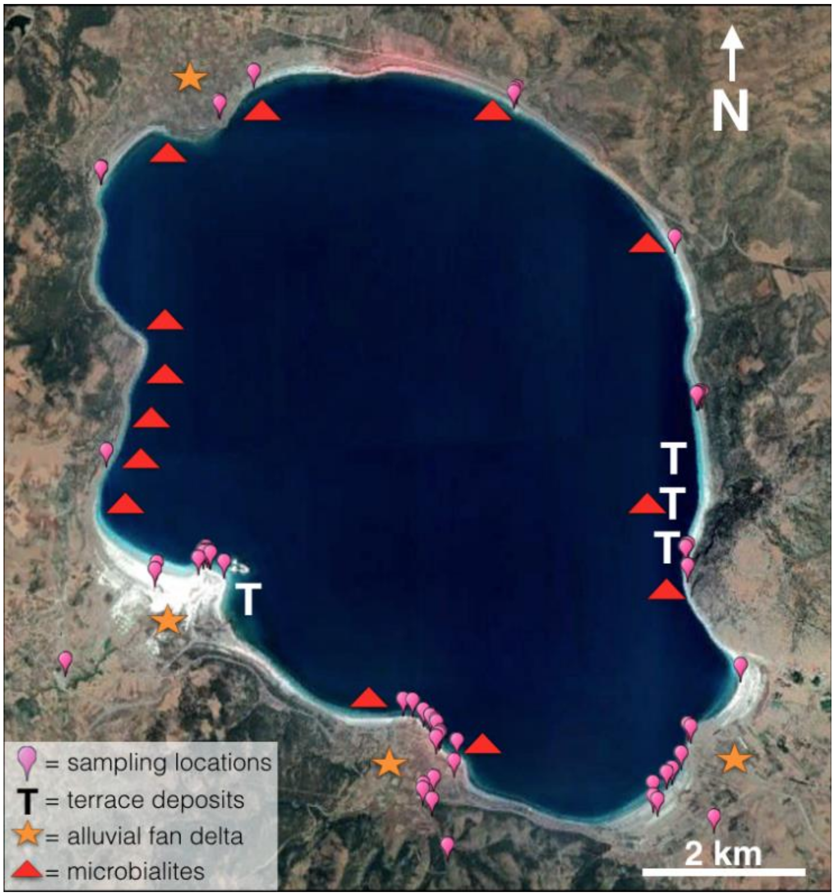

Figure 1: Google Earth image of Lake Salda with locations of representative deposit types and sample collection.

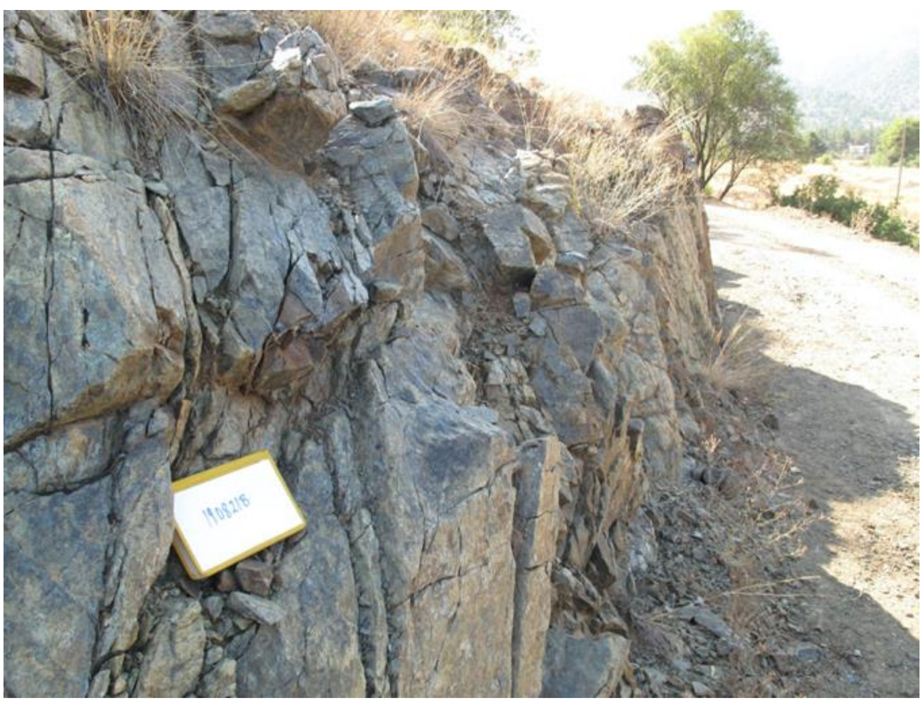

Figure 2: Ultramafic bedrock outcropping on the SSW side (37.511863° N, 29.683338° E).

Figure 3: Collecting a core sample along the shoreline (37.517104° N, 29.685482° E).

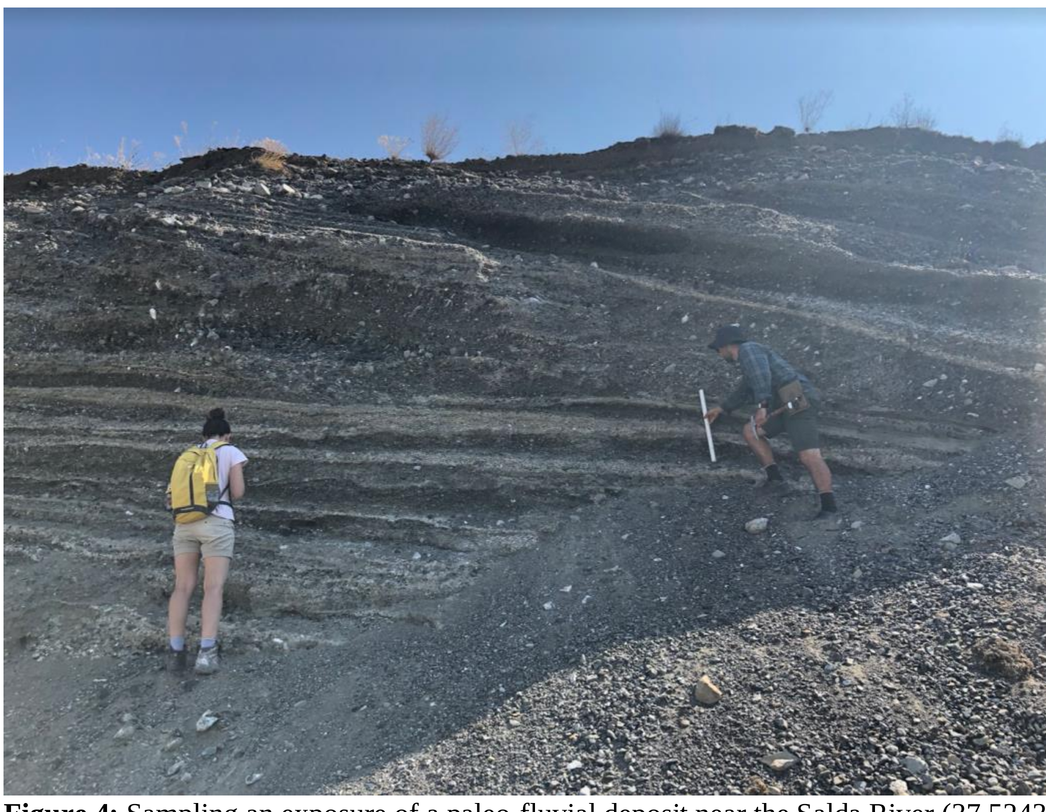

Figure 4: Sampling an exposure of a paleo-fluvial deposit near the Salda River (37.524336° N, 29.637971° E).

Figure 5: Terrace deposit at the Kocaadalar Burnu peninsula on the SW side of the lake (37.535098° N, 29.656341° E).

Figure 6: Microbialite at ~1.5 m depth near the eastern terrace deposits (37.535656° N, 29.716663° E).

Figure 7: Representative beach sediments with hydromagnesite (white) and ultramafic detrital (dark-toned) grains.