INVESTIGATING THE ORIGIN OF CARBONATE DEPOSITS IN JEZERO CRATER: MINERALOGY OF A FLUVIOLACUSTRINE ANALOG AT LAKE SALDA, TURKEY.

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Introduction: The Mars 2020 rover will investigate an ancient lacustrine environment at Jezero crater to search for signs of past life and cache samples for future return. Hydrated Mg-carbonate bearing deposits detected from orbit in the delta [1] and along possible ancient lakeshores [2] have high biosignature preservation potential and will be high priority targets for the rover. Understanding the nature of carbonate deposition at Jezero is important in constraining paleolake processes and refining search strategies for Mars 2020. Here we investigate a terrestrial lacustrine analog for Jezero to determine the distribution and mineralogy of authigenic and detrital sediments within a similar lake environment. In particular, we focus on characterizing clays and carbonates in various types of fluviolacustrine deposits based on VNIR spectral properties and XRD mineralogy, in order to better understand how orbital VNIR spectra at Jezero can be used to constrain the origin and biosignature preservation potential of various deposits.

Analog for Jezero: Lake Salda in SW Turkey is a unique analog for the Jezero paleolake (Fig. 1). Lake Salda is a deep (~196m) 45 km^2 alkaline (pH>9) lake surrounded primarily by ultramafic lithologies (mainly serpentinized ophiolite). Meteoric waters flowing through ultramafic rocks and alluvial sediment result in high Mg concentration within the lake [3]. Hydromagnesite, a hydrated Mg-carbonate, is the dominant precipitate and forms microbialites and lithified terraces around the lake perimeter [3,4]. Jezero crater is also surrounded by ultramafic terrains, contains hydrated Mg-carbonate bearing deposits, and has experienced fluvial input, making Lake Salda a high fidelity modern compositional and process analog for a Jezero paleolake.

Methods: We conducted fieldwork at Lake Salda in August 2019 to survey and sample representative deposit types around the lake perimeter. Our sample suite includes muds, deltaic deposits, microbialites, beach sediment, carbonate terraces, and watershed bedrock. We collected VNIR spectra (350-2500 nm) of each sample and categorized the samples based on spectral properties. Representative spectra from each category are shown in Figure 2 along with laboratory mineral spectra. VNIR mineral interpretations will be supported by bulk mineralogy from XRD and thermal-IR spectra.

Bedrock: Bedrock was directly sampled from outcrops around the lake and in the watershed, and is also represented by cobbles transported into the deltas and shorelines. The source bedrock is spectrally dominated by serpentine and other Fe/Mg phyllosilicates like chlorite, with no clear examples of unaltered units (Fig. 2). A large limestone butte outcropped on the eastern shoreline (Fig. 1a) does not contribute significantly to the detrital input at Lake Salda either as cobbles or sediments.

Detrital deposits: These include delta and beach sediments. Deltaic deposits occur at major fluvial inputs around the lake perimeter and consist of dark-toned large cobbles, sands, muds, paleosols, etc. (Fig. 3a). Some buried cobbles within deltaic deposits are encrusted with a 2-3 cm layer of hydromagnesite precipitates (Fig. 3b). These are similar to cobbles found around the modern shoreline, which display a thin veneer of hydromagnesite from periodic wetting and evaporation of the lake waters, and occasionally even display

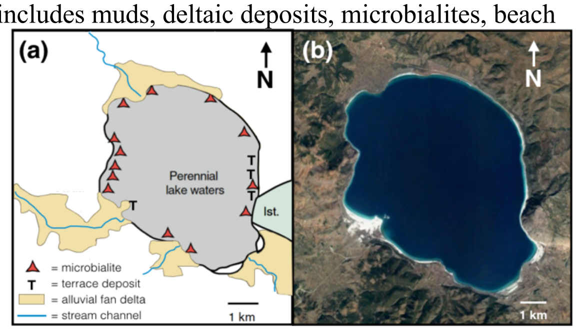

Figure 1: Lake Salda, Turkey. (a) Schematic map modified from [5]. (b) View of Lake Salda from Google Earth.

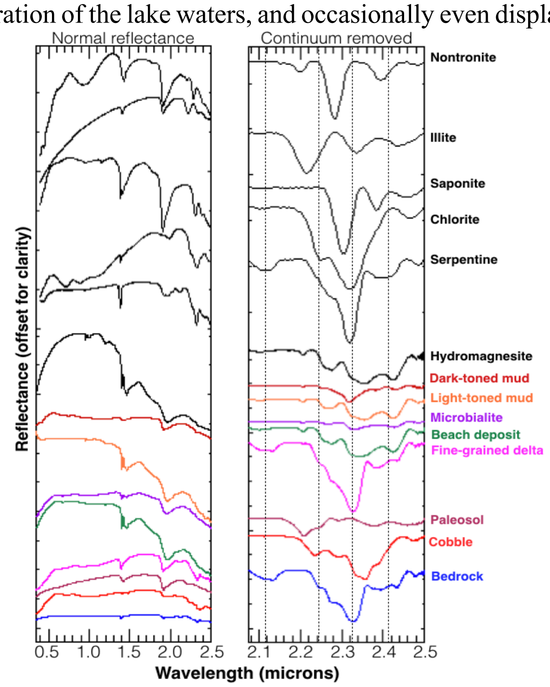

***Figure 2:** VNIR reflectance spectra of representative deposits.*

evidence of microbialitic growth (Fig. 3c). Beach sediments include sands and gravels comprised of a varying mixture of hydromagnesite (including broken up microbialites) and darker toned grains (Fig. 3d). Aside from the hydromagnesite-bearing beach deposits, the finer-grained detrital sediments are spectrally similar to the bedrock and cobble samples. One exception are fine grained samples from subsurface horizons in the southeastern delta, which are spectrally consistent with Al-smectites and visually consistent with paleosols (Fig. 2).

Carbonate structures: These include microbialite mounds and terrace deposits, and are all spectrally dominated by hydromagnesite. Microbialite mounds mostly occur as large subaerial stranded islands or as smaller younger deposits accreting subaqueously at meters depth with surficial microbial mats. Microbialites display pitted textures with poor lamination (Fig. 4a). Hydromagnesite terraces (Fig. 4d) are characterized by steep exposures of cemented hydromagnesite muds and sands, and occasionally preserve microbialite textures.

Muds: Two types of mud occur in the near shore environment. Light-toned muds that are spectrally consistent with hydromagnesite occur at the base of large terraces, in smaller hydromagnesite benches around the shoreline (Fig. 4c), and on the banks of the northern delta channel ~100 m from the present shoreline. Darker-toned muds are spectrally distinct from surrounding bedrock and delta clays, and are consistent with Fe/Mg smectites. They occur in elongated subaqueous mounds around the lake (Fig. 4b) and are also exposed at the shoreline near groundwater or fluvial input, including as distinct lenses within hydromagnesite muds at the base of terrace deposits on the western side.

Discussion: Lake Salda exhibits a variety of detrital and authigenic deposits. Delta sediments are spectrally similar to bedrock and cobbles, and the only clear signs of alteration in the deltas are limited to distinct paleosol horizons. Hydromagnesite is rare in the deltas and appears to be associated with paleoshorelines and not fluvial deposits, indicating that carbonates are only being precipitated within the lake. Carbonates occur on shoreline cobbles, in individual microbialites, large microbialite mounds, muds, and terraces, and erode to form hydromagnesite-rich sands and gravels in beach deposits. Lenses and mounds of darker-toned Fe/Mg-smectite muds are spectrally distinct from serpentine and chlorite in the source bedrock, suggesting an authigenic origin. The occurrence of these muds within the lake may be due to groundwater or fluvial input, but further study is needed to confirm formation mechanisms.

These results may help inform our understanding of processes in the Jezero paleolake. While Mg-carbonates in the Jezero delta are likely to be detrital [1], they may also represent carbonate accumulation on deltaic surfaces. Marginal deposits in Jezero near the fluvial input are composed of a mixture of watershed minerals and possibly additional carbonate [2], potentially consistent with the mixture of detrital sediments and broken up lacustrine carbonates on Lake Salda beaches. More carbonate-dominated deposits detected along the margins of the crater [2] may represent authigenic shoreline precipitation, similar to the mud, mound, and terrace deposits at Lake Salda. Al-clays in the Jezero delta [2] may represent sites of in situ surface weathering.

References: [1] Goudge et al. (2015) *JGR, 120,* 775-808. [2] Horgan et al. (2020) *Icarus*, 339, 113526. [3] Braithwaite and Zedef (1996) *Journal of Sedimentary Research, 5,* 991-1002. [4] Russell et al. (1999) *Journal of the Geological Society, 156,* 869-888. [5] Warren (2016) *Springer*, 303-380.

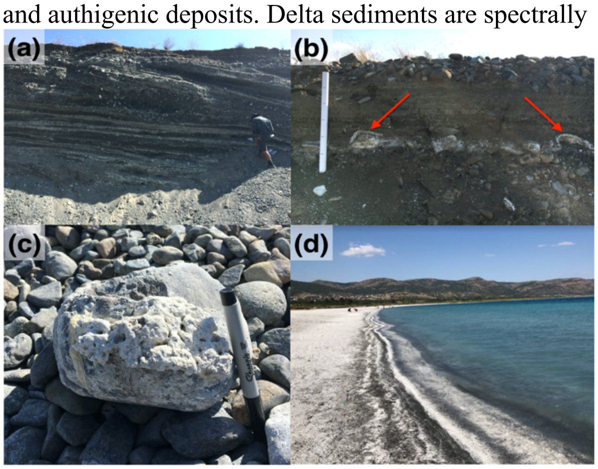

Figure 3: *Detrital deposits. (a) Outcrop of a fluvial deposit. (b) Distal end of deltaic deposit. Buried cobbles are coated with a layer of hydromagnesite. (c) Shoreline cobble at distal end of delta with microbialitic growth. (d) Typical beach deposit with a mixture of hydromagnesite and ultramafic grains.*

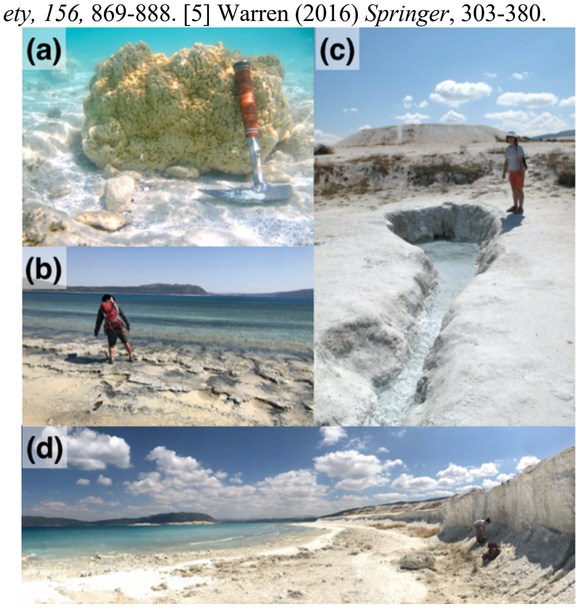

Figure 4: *Carbonate structures and muds. (a) Microbialite growing at ~1.5 m depth (b) Dark toned mud mounds. (c) Hydromagnesite mud at a groundwater spring. (d) Terrace.*