EXPECTED RESULTS OF CARBONATE INVESTIGATIONS BY THE PERSEVERANCE ROVER IN JEZERO CRATER: LESSONS FROM A FLUVIOLACUSTRINE ANALOG AT LAKE SALDA, TURKEY.

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Introduction: The Perseverance rover on the Mars 2020 mission will explore an ancient lacustrine environment at Jezero crater to investigate regional geology, evaluate past habitability, seek signs of ancient life, and cache samples for future return to Earth [1]. Mg-carbonate spectral signatures have been detected from orbit in the basin fill, in the deltas and fans, and along the crater margin [2,3]. While carbonates are present throughout the region [4], the carbonates in Jezero may have been modified or deposited by fluvial and lacustrine activity. Carbonates in the delta may be detrital [3] and those along the crater margin may be due to authigenic precipitation [2]. The latter in particular could imply high biosignature preservation potential and thus will be high priority targets for the rover.

Understanding the nature of carbonate deposition at Jezero is important in constraining paleolake processes and refining biosignature search strategies for Mars 2020. In this study, we investigate a terrestrial lacustrine analog to develop strategies for determining the origin and biosignature preservation potential of the carbonate-bearing deposits the Perseverance rover will encounter in Jezero. Here we present field observations and visible/near-infrared (VNIR; 0.3-2.5 μm) spectra of deposits at Lake Salda that are analogous to VNIR spectra from Mastcam-Z and SuperCam and discuss expected results at Jezero crater.

Lake Salda, Turkey: [2] identified Lake Salda in southwestern Turkey as a unique analog for the Jezero paleolake (Fig. 1). Lake Salda is a deep (up to ~196m) 45 km^2 alkaline (pH>9) closed basin lake surrounded primarily by ultramafic lithologies (mainly serpentinized ophiolite), with localized outcrops of dunite and limestone (lst. in Fig. 1) [5]. It is one of the only known deep and perennial lakes on Earth where 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 by meteoric waters [6]. Deposit types in Lake Salda include delta and beach sediments, microbialites, muds, and carbonate terraces.

We sampled source rocks in the Lake Salda watershed from bedrock outcrops near the lake and cobbles transported into the deltas and shorelines. These rocks are spectrally dominated by serpentine and other Fe/Mg phyllosilicates (Fig. 3). Deltaic deposits occur at major fluvial inputs around the lake perimeter and consist of dark-toned large cobbles, sands, and muds that are spectrally similar to the source material. The only signs of alteration in deltas are limited to distinct paleosol horizons near the southeastern shoreline. Some buried cobbles within the deltaic deposits are encrusted with a 2-3 cm layer of hydromagnesite possibly precipitated along a paleoshoreline. Beach deposits are comprised of a varying mixture of hydromagnesite (including broken up microbialites) and dark toned detrital grains, which increase in abundance near deltas or steep outcrops.

Microbialites are spectrally dominated by hydromagnesite and occur in shallow near shore environments and as large subaerial islands. Light-toned terraces ~10-15m high are composed of cemented hydromagnesite muds and sands deposited when lake level was higher, and occasionally preserve microbialite textures that are several hundred years old [7]. Light-toned hydromagnesite muds occur at the base of large terraces, in smaller benches around the shoreline, and on the banks of delta channels. Darker-toned muds occur in subaqueous mounds around the lake and are also exposed at the shoreline near groundwater or fluvial input. They are spectrally distinct from bedrock and delta clays, and are consistent with Fe/Mg smectites (Fig. 3).

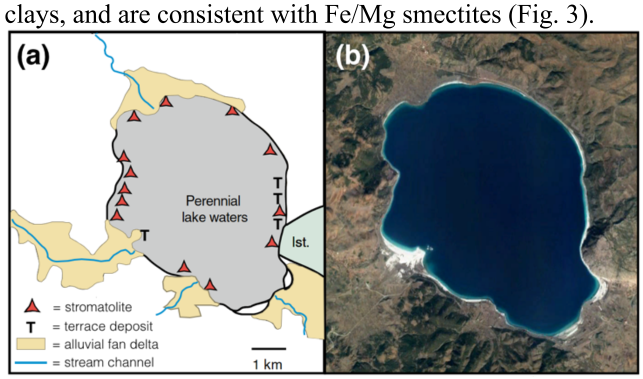

Figure 1: *Lake Salda, Turkey. (a) Schematic map modified from Warren (2016) [8]. (b) General view of Lake Salda from Google Earth.*

Comparisons to Jezero from Orbit: Orbital observations of Jezero crater reveal geologic features similar to those at Lake Salda, including surrounding altered and Mg-rich ultramafic terrains, Mg-carbonate bearing deposits, and fluvial input into a deep and large lake during a closed basin phase. Weak Mg-carbonate signatures are observed within the crater floor basin fill, which is spectrally dominated by olivine and possible mixtures of carbonate and Fe/Mg phyllosilicates [2]. While these deposits may represent a sub-unit of the regional carbonate-bearing terrain or detrital material, some of the carbonates here may be lacustrine precipitates, similar to the mixture of authigenic hydromagnesite and detrital ultramafic muds observed near the shoreline and in lake bottom cores at Lake Salda [9].

In the delta, Mg-carbonate and olivine signatures are restricted to the curvilinear regions that have been interpreted as point bar deposits [10]. While Mg-carbonates in the Jezero delta are likely to be detrital, they may also represent carbonate accumulation on deltaic surfaces, similar to the hydromagnesite precipitates observed on buried cobbles at Lake Salda.

The strongest carbonate spectral signatures in Jezero occur along the western inner margin and may represent authigenic nearshore carbonates [2]. The marginal deposits near the fluvial input are composed of a mixture of phases found in the watershed and possibly additional carbonate, potentially consistent with the mixture of detrital sediments and broken up lacustrine carbonates observed on Lake Salda beaches.

Testing hypotheses with Perseverance: Results from our study of Lake Salda may help inform our rover investigations of the carbonate-bearing deposits in Jezero to determine depositional origin. Outcrop and fine-scale textural imaging as well as mineralogical investigations with Supercam and Mastcam-Z will help identify potential precipitates. For example (Fig. 3), Mastcam-Z can detect variations in carbonate hydration near ~1000 nm associated with lacustrine precipitates, and SuperCam can detect carbonate and phyllosilicate absorptions between 2200-2600 nm.

If the Mg-carbonates in the crater floor are authigenic, the rover may expect to observe fine carbonate grains intimately mixed or layered with detrital muds from the watershed, or overgrowths of carbonate. This may distinguishable from carbonate of another origin, such as a weathered tephra, which may contain a more heterogenous mix of carbonate coatings and unaltered olivine-rich parent material with primary depositional textures. Lacustrine precipitates in the delta may be preserved as beach deposits or buried carbonate in the point bars. The rover may expect to observe overgrowths on detrital cobbles with high carbonate content, pure carbonate grains broken up by wave action, or microcrystalline to visible crystals or layers of primary precipitates. If detrital, carbonate and other grains may be more sorted due to varying energy regimes during deposition. Authigenic Mg-carbonates along the western margin may present as terrace or beach deposits, with higher carbonate content and possibly preserved biogenic textures. If detrital, the rover may expect to observe sorting of carbonate grains, with grain size decreasing with distance from inlet.

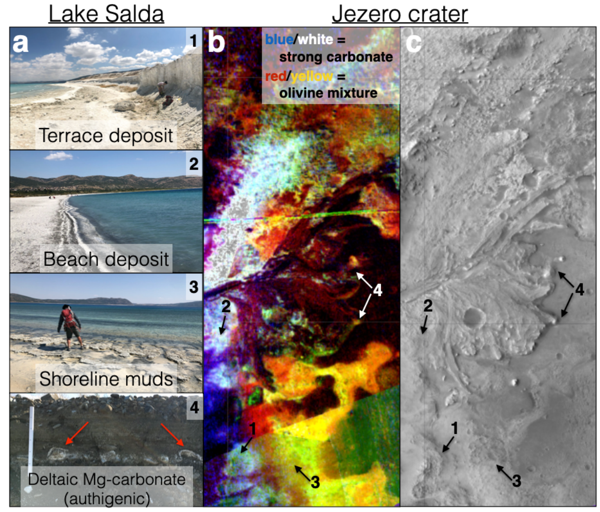

Figure 2: *Comparison of Lake Salda and Jezero deposits. (a) Representative Lake Salda deposits. (b) CRISM spectral parameter map modified from [2] showing diversity of carbonate signatures in Jezero. (c) CTX mosaic. Numbers in (b) and (c) indicate potential locations of deposit types corresponding to those numbered in (a).*

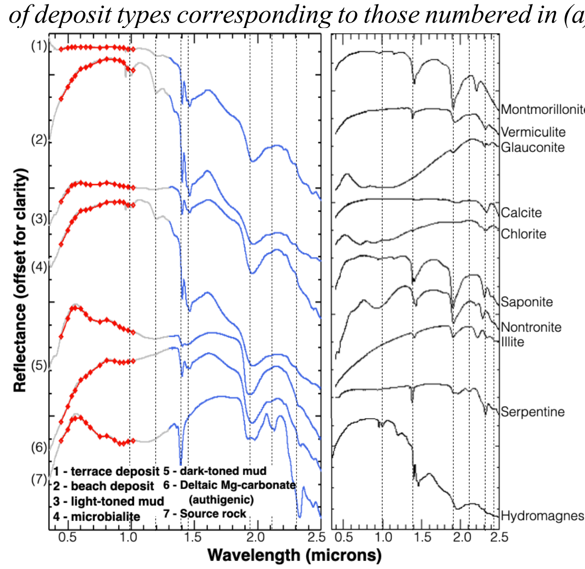

Figure 3: *VNIR reflectance spectra of representative deposits at Lake Salda as full-resolution (gray lines) and convolved to Mastcam-Z bandpasses (red circles). Blue line displays upper range observed by SuperCam (1.3-2.6 μm). Reference spectra shown in right panel.*

References: [1] Williford et al. (2018) *Elsevier,* 275-308. [2] Horgan et al. (2020) *Icarus*, 339, 113526. [3] Goudge et al. (2015) *JGR, 120,* 775-808. [4] Ehlmann et al. (2008a) *Science*, 322 (5), 1828. [5] Russell et al. (1999) *Journal of the Geological Society, 156,* 869-888. [6] Braithwaite and Zedef (1996) *Journal of Sedimentary Research, 5,* 991-1002. [7] Balci et al. (2020) *Geomicrobiology Journal*, 37 (5), 401-425. [8] Warren (2016) *Springer*, 303-380. [9] Danladi et al. (2018) *Quaternary International*, 486, 185-198. [10] Schon et al. (2012) *Planetary and Space Science*, 67 (1), 28-45.