SEARCHING FOR POTENTIAL BIOSIGNATURES IN JEZERO CRATER WITH MARS 2020 – AN INVESTIGATION OF TERRESTRIAL LACUSTRINE CARBONATE ANALOGS.

B. J. Garczynski[1], B. Horgan[1], L.C. Kah[2], [1]Dept. of Earth, Atmospheric, and Planetary Sciences, Purdue University, West Lafayette, IN (bgarczyn@purdue.edu), [2]Dept. of Earth and Planetary Sciences, University of Tennessee, Knoxville, TN

Introduction: The Mars 2020 rover will investigate an ancient lacustrine environment at Jezero Crater to search for signs of ancient life and cache samples for future sample return. Hydrated Mg-carbonate bearing deposits detected from orbit have a high potential for preservation of biosignatures, and will be high priority targets for the rover. Carbonate-bearing deposits in the Jezero delta may reflect detrital sedimentation [1], and some hydromagnesites along the margin of the crater may reflect near-shore precipitation [2]. Developing strategies for where to look for biosignatures in these carbonate deposits is important for maximizing the scientific return of the Mars 2020 mission. In particular, we aim to determine which deposit types (e.g., delta, quiescent lake shore precipitates, etc.) may best preserve biosignatures that could be detectable by Mars 2020. Here we present an overview of four potential lacustrine analogs for Jezero crater and preliminary results from orbital spectral analysis using Hyperion hyperspectral imagery.

Analogs for Jezero: We present four sites that represent alkaline lacustrine or playa environments that are dominated by hydromagnesite minerals (Fig. 1). The Mg-rich waters are a result of surface- and groundwater interaction with a surrounding ultramafic to mafic terrain similar to that present in Jezero Crater.

Cariboo Plateau, British Columbia: Playas and ephemeral lakes of the Cariboo Plateau are fed directly by groundwater discharge via marginal springs and seeps, snowmelt, and unchanneled wash. In most areas, hydromagnesite and magnesite-bearing mud extends to depths greater than ~30 cm, and overlies sediments containing dolomite, aragonite, Mg-calcite, and calcite. These sediments have a sharp contact with several decimeters of dense clay, which overlies glaciofluvial sand and gravel. Mineral stratigraphy suggests increasing Mg/Ca ratios in the water through time, possibly resulting from an increase in aridity and early removal of Ca^{2+} from groundwaters by precipitation of calcite.

Microbialites are common in subaqueous environments and along lake margins where moisture is provided by shallow groundwater. Mats that develop on the margins of the playas are commonly mineralized by capillary evaporation and *in situ* hydromagnesite precipitation, some of which may be bio-induced. Mats formed subaqueously tend to be less mineralized, but have greater morphological variation. Low preservation of the mats results from degradation during wet-dry cycles, bioturbation, etc. [3].

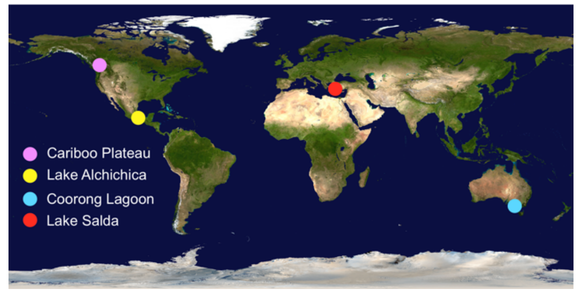

Figure 1: *Map showing the locations of the analog sites.*

Lake Alchichica, Mexico: A 2.26 km^2 alkaline (pH~8.9), hyposaline crater lake [4] is located in the Central Mexico Plateau at 2300 m elevation, with a maximum depth of 63 m [5]. The crater is surrounded by an asymmetric tuff ring and lake waters are supplied by groundwater that infiltrates from Cretaceous-aged calcareous strata in mountains to the east and Mg-rich silicate minerals in volcanic tephra. Waters are Mg-rich (Mg/Ca = 40) and oversaturated with respect to both magnesium and calcium carbonate. Microbialites occur to a depth of ~15 m, and are composed primarily of hydromagnesite minerals that have diagenetically replaced primary aragonite [6]. Emergent, subfossil microbialites consist of (1) older "white" domes and crusts comprised mainly of diagenetic hydromagnesite with an admixture of huntite and calcite, and (2) younger "brown" chimneys, columns, and laminated crusts composed mostly of aragonite with an admixture of Mg-calcite, which cements the volcanic sand occurring between microbialites. Mineralogical, textural, and isotopic differences suggest "white" microbialites formed in a dry period while "brown" microbialites formed in a wetter climate when high water level and increased inflow lowered Mg/Ca ratio, resulting in aragonite precipitation [6].

Coorong Lagoon, Australia: In the Coorong, saline lagoons occur separated from marine environments by cemented beach dunes. Ephemeral alkaline lakes occur at the southern end of the lagoon in regions more isolated from marine influence, and are dominated by groundwater input. Carbonate minerals precipitate during annual evaporative phases and include dolomite, magnesite and hydromagnesite, magnesian calcite, aragonite and monohydrocalcite [7]. Mineralized microbialites are localized to regions with substantial groundwater-influx [8]. These regions host well-developed microbial mats at lake margins, which are associated with aragonite-hydromagnesite surficial sediment. In the subsurface, aragonite is replaced by calcite, and then by a calcite-dolomite assemblage [9].

Lake Salda, Turkey: A 45 km^2 alkaline (pH > 9), freshwater lake surrounded by ultramafic (mainly serpentinized ophiolite) lithologies to the north, west, and south, and dolomitized limestone to the east (Fig. 2). Meteoric waters flowing through ultramafic rocks and alluvial sediment result in high Mg concentration within the lake [10]. Hydromagnesite is the dominant precipitate and is abundant in microbialites that occur on the lake perimeter. Microbialites and are well developed at the mouths of dry stream valleys, indicating at least ephemeral fluid flow. Emergent fossil to subfossil microbialites occur discontinuously around the lake, although morphological structures are poorly preserved [11]. Lithified hydromagnesite terrace deposits located on the southwest peninsula and eastern shore lack *in situ* evidence for microbial colonization and likely result from reworking of lake sediment [10].

Orbital Spectroscopy: To investigate the composition of Lake Salda from orbit, we atmospherically corrected an EO-1 Hyperion hyperspectral image using FLAASH in ENVI. Initial analysis of the corrected image indicates carbonate spectral signatures along the perimeter of the lake. Stronger signatures occur on the eastern margin away from the deltas (Fig. 3). Investigation of specific types of carbonates at various absorption wavelengths (e.g., magnesite at 2.30 μm, dolomite at 2.32 μm, calcite at 2.34 μm [12]) is inconclusive due to insufficient SNR of the data.

Discussion: A review of four terrestrial sites suggests that microbialites in hydromagnesite producing lakes on Earth are commonly mineralized by hydromagnesite. Thus, if microbial activity were present in Jezero crater, hydromagnesite deposits may provide a target for biomarker preservation. Formation of microbialites can occur both along evaporative margins and in shallow-sloping subaqueous lake environments, although preservation appears largely to be restricted to low energy shorelines that have not been reworked by wave activity.

Shoreline deposits that occur in regions distinct from fluvial-deltaic deposits at Lake Salda exhibit stronger carbonate signatures, presumably reflecting the absence of mixing with other detrital minerals. A similarly strong carbonate signature has been identified within marginal deposits in Jezero crater, and may support the hypothesis that these deposits include authigenic shoreline carbonates [2]. However, it is likely difficult to determine from orbital data alone whether or not deposits reflect reworked carbonate sediment (with low preservation potential for biosignatures) or *in situ* mineral deposits (with high preservation potential for biosignatures). Based on these results, we conclude that the Mars 2020 rover should target possible biosignatures in any carbonate-bearing near-shore deposit at Jezero.

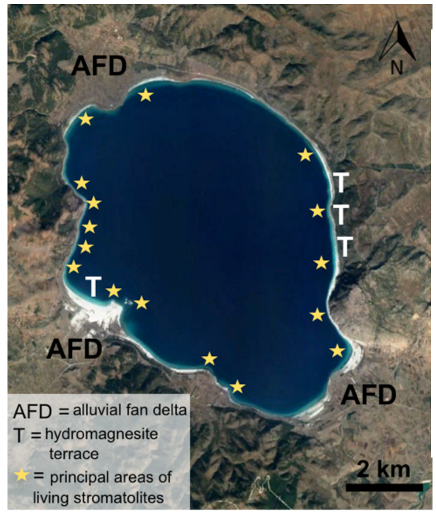

***Figure 2:** A Google Earth image of Lake Salda with locations of terrace deposits (T), alluvial fan deltas (AFD), and stromatolites (star) marked [10,11].*

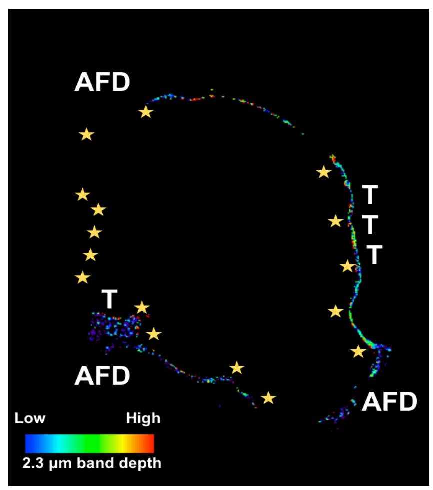

***Figure 3:** Sum of band depth maps centered at 2.30 μm, 2.32 μm, and 2.34 μm showing carbonate absorption on the Lake Salda shoreline, with locations of features from Fig. 2 (water and surrounding terrain is masked).*

References: [1] Goudge et al. (2015) *JGR, 120,* 775-808. [2] Horgan et al. *Icarus*, *in revision*. [3] Renaut (1993) *Hydrobiologia, 267,* 75-98. [4] Vilaclara et al. (1993) *Verhandlungen der Intl. Vereinigung für Limnologie, 25,* 435-440. [5] Filonov et al. (2006) *GRL, 33,* L07404 [6] Kaźmierczak et al. (2011) *Facies, 57,* 543-570. [7] von der Borch (1965) *Geochimica et Cosmochimica Acta, 29,* 781-799. [8] von der Borch (1976) *Developments in Sedimentology, 20,* 413-420. [9] Walter et al. (1973) *Journal of Sedimentary Petrology, 43,* 1021-1030. [10] Braithwaite and Zedef (1996) *Journal of Sedimentary Research, 5,* 991-1002. [11] Russell et al. (1999) *Journal of the Geological Society, 156,* 869-888. [12] Bishop et al. (2013) *44th LPSC* #2555.