Dried Lakes in Western United States as Analogue to Desiccation Fractures on Mars.

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Introduction: Potential Desiccation Polygons (PDPs, Fig. 1) 10s–100s of meters in size, have been observed in numerous regions on Mars, particularly in ancient (>3 Gyr-old) terrains of inferred paleo-lacustrine/playa geologic setting, and in association with hydrous minerals such as smectites (see [1] for a review). Therefore, a better understanding of the conditions in which large desiccation polygons form could yield unique insight into the ancient climate on Mars. Many dried lakebeds in western United States display large (>50 m-wide) desiccation polygons (Fig.1), which we consider to be analogues for PDPs on Mars. Therefore, we have carried out fieldwork in seven of these dried lakes in San Bernardino and the Death Valley National Park regions complemented with laboratory and spectral analysis of collected samples.

Fieldwork and methods: The western United States contains many playas and dried lakes. Among these, a small subset of these locations displays large desiccation fractures. For this study, seven sites were chosen that cover a wide range of surface morphologies in order to carry out a geological and compositional comparison (Table 1). In terms of geography, three of these sites are located in San Bernardino County (Coyote, Lucerne, Soggy), three are located in the Death Valley National Park (Mesquite, Racetrack, North Panamint) and one location in Inyo Country (Deep Springs). The fieldwork generally consisted of two main tasks: 1) characterizing the surface morphology of the site mainly through imaging using commercial DSLRs, and 2) collecting samples directly from the surface and ~15–30 cm-deep in order to assess possible vertical variation and effect of surface weathering. The lab analysis consisted of three main techniques: 1) X-ray Diffraction (XRD) analysis to derive chemical composition and mineralogy, 2) Laser Diffraction (LD) to derive particle-size distribution, and 3) Visible-Near Infrared (Vis-NIR) analysis to characterize the spectral properties, and to assess similarities and differences with Martian remote sensing measurements.

Results: In total, seven different locations were investigated in this study. Four of those display large desiccation fractures, two display small cm-sized polygons, and one salt-rich playa displays meter-sized salt polygons but no conventional desiccation features. In terms of mineralogy, no discernable trends exist that would distinguish the sites showing large desiccation fractures from the ones that do not. In fact, all locations show roughly a few common attributes from geologic investigations, XRD and LD analysis: 1) a soil

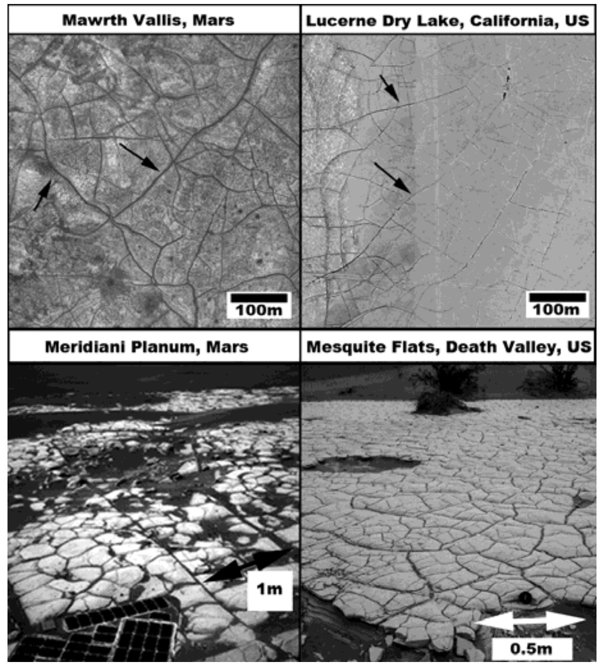

Fig. 1. Potential desiccation polygons (PDPs) on Mars in comparison to desiccation polygons on Earth. Mars displays PDPs that span a wide size range from centimeters to 100s of meters.

#	Location	Coordinates	Context
1	Lucerne Lake (San Bernardino)	34°29'45.70"N, 116°57'8.6"W	Large polygons
2	Coyote Lake (San Bernardino)	35° 4'11.27"N, 116°43'41.1"W	Large polygons
3	Soggy Lake (San Bernardino)	34°27'7.02"N, 116°41'15.4"W	Large polygons
4	North Panamint Lake (DVNP)	36°24'22.9"N, 117°24'53.4"W	Large polygons
5	Mesquite flats (DVNP)	36°36'36.57"N, 117°6'45.9"W	cm-sized polygons
6	Racetrack Playa (DVNP)	36°41'39.1"N, 117°34'03.2"W	cm-sized polygons
7	Deep Springs Playa (Inyo)	37°16'31.63"N, 118°2'18.2"W	Salt polygons

Table 1. List of sites visited for fieldwork. “Large” signifies 10s of meters-wide desiccation polygons.

matrix with significant clay and fine silt content (~50% on average), 2) illite/muscovite-dominated clay content (~60% on average of the clay content) with significant amounts of smectite, and 3) carbonaceous mineralogy with variable amounts of salts, mainly as chlorides and in some cases sulfates. With regards to Vis-NIR analysis, Most of the samples show similar absorption features where all the samples show deep absorptions at ~1.90–1.91 µm, except for thenardite-dominated (Na_2SO_4) samples (Deep Springs samples) that shows a broader absorption centered at ~1.93 µm, and most show absorptions of variable depth at ~1.41 µm. The samples may be slightly distinguished from each other by the presence/absence of absorptions near 2.21 and 2.31 µm. In general, the samples acquired in the San Bernardino and Mojave regions appear to have stronger absorptions than those of the Death Valley region. This difference does not appear to be related to grain-size as no discernable trend could be identified in the LD analysis, but instead could indicate that the samples in the Death Valley region are simply less hydrated. It is important to note that the 2.34–2.35 absorption feature is markedly lacking or highly ambiguous in the spectra despite the dominance of Illite/Muscovite in the samples. We cannot attribute this ambiguity to instrumental limits because we are able to discern such absorption features in the reference minerals we measured, including Illite. In the absence of such absorptions, we would not be able to identify Illite/Muscovite in our samples without a priori knowledge.

Discussion: Early studies [e.g., 2] argue that large desiccation polygons should develop in association with intense evaporation and lowering of ground-water levels rather than simple evaporation from the surface. Regional water table maps [3] for the San Bernardino region clearly show a decline in water table levels since the 1950s in many regions. If indeed water table retreat was a key factor in the formation of large desiccation features, we would assume that such a mechanism has been lacking, at least on the same scale, in Death Valley, where the Racetrack and Mesquite sites are located. The Mesquite flats are situated in one of the low elevation points of the valley (~15 m below sea level), which makes it a preferred location for groundwater discharge [4]. On the other hand, the high elevation of Racetrack playa (~1130 m above sea level) places it well above ground water levels but facilitates regular precipitation through heavy downpour or more commonly through snow accumulation in winter [5]. As a result these two sites (showing only small cm-sized desiccation features) are dominated by surface evaporation processes rather than water table retreat.

Summary: Our study shows that the investigated lacustrine/playa sediments have a) a soil matrix containing ~40–75% clays and fine silt (by volume) where the clay minerals are dominated by illite/muscovite followed by smectite, b) carbonaceous mineralogy with variable amounts of chloride and sulfate salts, and significantly, c) roughly similar spectral signatures in the visible-near-infrared (VIS-NIR) range. We conclude that the development of large desiccation fractures is consistent with water-table retreat. In addition, the comparison of the mineralogical to the spectral observations further suggests that remote sensing VIS-NIR spectroscopy has its limitations for detailed characterization of lacustrine/playa deposits.

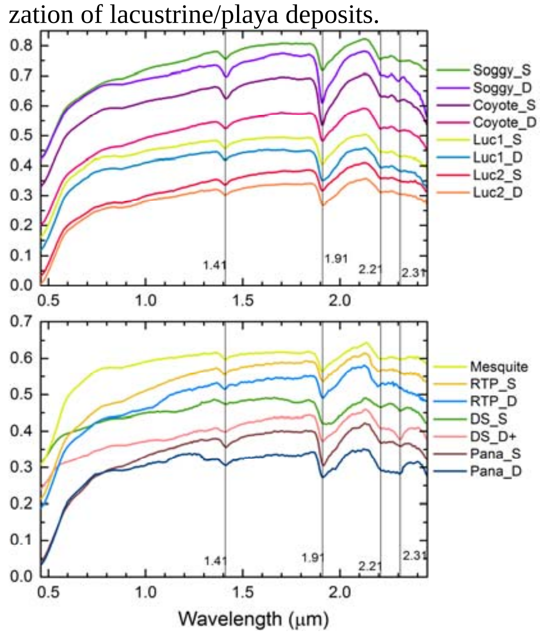

Fig. 2. VIS-NIR spectra of field samples. The upper panel shows spectra in the San Bernardino County whereas the lower panel shows the rest of the samples in the Death Valley National Park and Inyo County. The acronyms/abbreviations are as follows: LUC1: Lucerne Lake site#1, LUC2: Lucerne Lake site#2, RTP: Racetrack playa, DS: Deep Spring Lake, Pana: North Panamint Lake. Finally, "S" and "D" represent "surface" and "at depth" samples, respectively. Note the similarities in absorptions in almost all samples.

References: [1] El-Maarry M.R et al., (2014), Icarus 241, 248–268. [2] Neal J.T. et al., (1968), Geol. Soc. Am. Bull. 79, 69–90. [3] http://www.mojavewater.org/regional-water-table.html. [4] Bedinger, M.S., and Harrill, J.R. (2012), Natural Resource Technical Report NPS/NRSS/WRD/NRTR—2012/652. [5] Lorenz, R.D. et al., (2011), J. App. Meteor. & Clima. 50, 2361–2375.