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Potential Desiccation Cracks on Mars as Indicators of Paleolacustrine Sites: Implications for Future Exploration

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Abstract

The HiRISE instrument has aided in the identification of polygonal crack patterns in association with phyllosilicate-bearing terrains in low to mid-latitudes on Mars, which have been suggested to be potential desiccation cracks. In this study, we summarize and review the global observations of such polygonal patterns and assess their morphology, mineralogy, geologic setting and global distribution as well as their implications for future exploration.

1. Introduction

HiRISE has aided in the identification of polygonal crack patterns in association with phyllosilicate-bearing terrains in low to mid-latitudes, which have been identified as potential desiccation cracks [1–6] (Fig. 1). Moreover, The MER-Opportunity and the MSL-Curiosity rovers have observed similar patterns on a much smaller scale [7, 8]. These observations suggest that desiccation cracks and polygons may be more common on the surface of Mars than previously thought. This could have profound implications for our understanding of the history of water on Mars, its early climate, and consequently, our choice of candidate landing sites for future exploration (e.g., ExoMars 2018 and 2020 mission). In this study, we summarize and review the global observations of such polygonal patterns and assess their morphology, geologic setting and global distribution.

2. Potential desiccation polygons (PDPs) on Mars

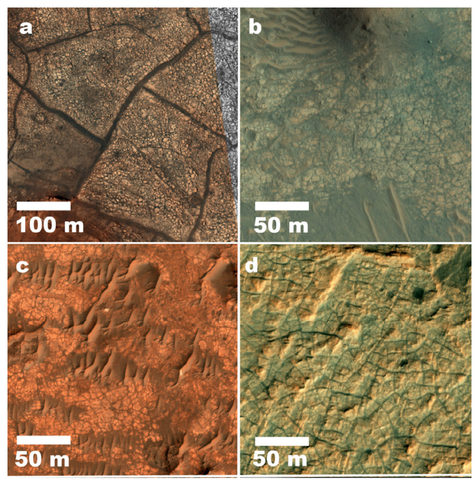

Figure 1: Potential desiccation polygons (PDPs) on Mars as observed by HiRISE in Mawrth Vallis (a), Libya Montes (b), Margaritifer Terra (c), and chloride-bearing terrains in Terra Sirenum (d).

PDPs are a common feature in phyllosilicate- and chloride-bearing terrains [6, 9] and have been observed with size scales that range from cm- to 10s of meters-wide using images from HiRISE and currently active rovers. The global distribution of PDPs shows that they share certain traits in terms of morphology and geologic setting that can aid in their identification and distinguish them from fracturing patterns caused by other processes (Fig. 2). Most PDPs currently observed attain a size range of 2–30 meters-wide. PDPs are almost exclusively observed in light-toned units with respect to the surrounding terrain. They commonly underlie dark-toned materials, which are often

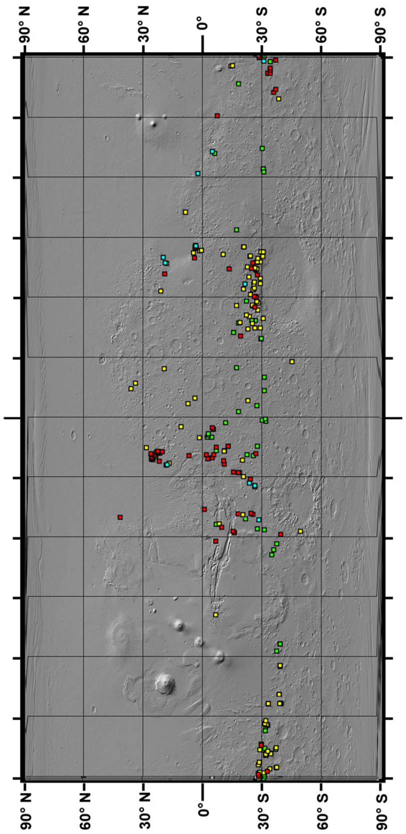

Figure 2: MOLA-based shaded relief map for PDP locations on Mars. The dataset includes crack patterns in smectite-bearing deposits that are observed either as horizontal beds (yellow), crustal outcrops (red), or deltas/alluvial fans (light blue). Also included are the cracking patterns in chloride-bearing terrains [8,12] (green). PDPs are clustered in certain localities in the southern highlands, which include Mawrth Vallis, Sirenum and Margaritifer Terra, eastern Valles Marineris, circum-Isidis (Nili Fossae and Libya Montes), and northern circum-Hellas

spectrally featureless and display signs of recent exhumation. PDPs are generally flat and usually subdivide extensively to form secondary to multiple generations of cracks in a fractal-like pattern that is embedded within the larger primary polygons and re-quires images with sub-meter spatial resolution to identify them. PDPs are mostly associated with sedimentary deposits that display spectral evidence of Fe/Mg smectites in addition to Al-rich smectites and less commonly kaolinites, sulfates and carbonates. In contrast, PDPs are uncommon in materials that have been heavily modified by erosion, tectonism, or extensive reworking (e.g., central-peak materials uplifted by impact cratering). Similarly, they are uncommon in materials of possible geothermal or hydrothermal origin, which is inferred from the presence of high-temperature/pressure mineral phases such as chlorites, prehnite and serpentine.

3. Implications

PDPs can be excellent markers for paleolacustrine environments and their presence implies that the fractured units are rich in smectite minerals [6]. Together, the following criteria make a certain location a high candidate for a paleolacustrine site on Mars: 1) detection of Fe/Mg smectites along with salts, carbonates, kaolinite, and possibly illite, 2) absence of high temperature/pressure phases, and 3) association with polygonal patterns resembling PDPs. These are top-priority settings for in-situ exploration and search for paleo-organic materials. The presence of PDPs in association with many phyllosilicate exposures that are located in natural basins and/or are of sedimentary origin would argue for a more hydrologically active period and warmer conditions than what is observed today. However, the presence of desiccation features is similarly consistent with climatic conditions that display only short, intermittent hydrological activity characterized by ground-water activity in generally arid conditions.

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