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Crater Floor Polygons: Desiccation Patterns of Crater Paleolakes?

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Abstract

Polygons in crater floors on Mars have been reported before in literature. However, they have been scarcely discussed in terms of their distribution on Mars as well as their mode of formation. We report here on their distribution in both the northern and southern hemispheres on Mars as well as discuss briefly the main physical mechanisms that may be responsible for their formation. We also discuss possible analogs on Earth. Our future work will involve modelling the physical processes that could form these polygons in order to better constrain their mode of formation which should have major implications on our understanding of how these structures evolve with time under past and current Martian conditions.

Introduction:

Crater-floor polygons have been reported before by [1]. The authors identified this feature through the use of the high resolution Mars Orbital Camera (MOC) images that were available at that time, among three other types of polygons in the circumpolar regions on Mars. Crater-floor polygons (CFPs) show a range of size from 75 to 200 meters in width, and have variable shapes, with mostly an orthogonal pattern of intersecting cracks. This cracking pattern resembles, albeit on a larger scale, those of dried-up karst lakes on Earth in certain periglacial environments such as Tuktoyaktuk in Canada [2], and even ancient desiccated lakes such as Coyote and Guano Lakes in the USA [3]. Using a larger database of high resolution images, i.e., complete data set of MOC, in addition to HiRISE and Context Imager (CTX), we build-up on the work of [1], by mapping all the craters that show cracked polygonal patterns in their floors. Our future work involves modelling these features to investigate whether they are in fact, desiccation patterns or thermal contraction polygons.

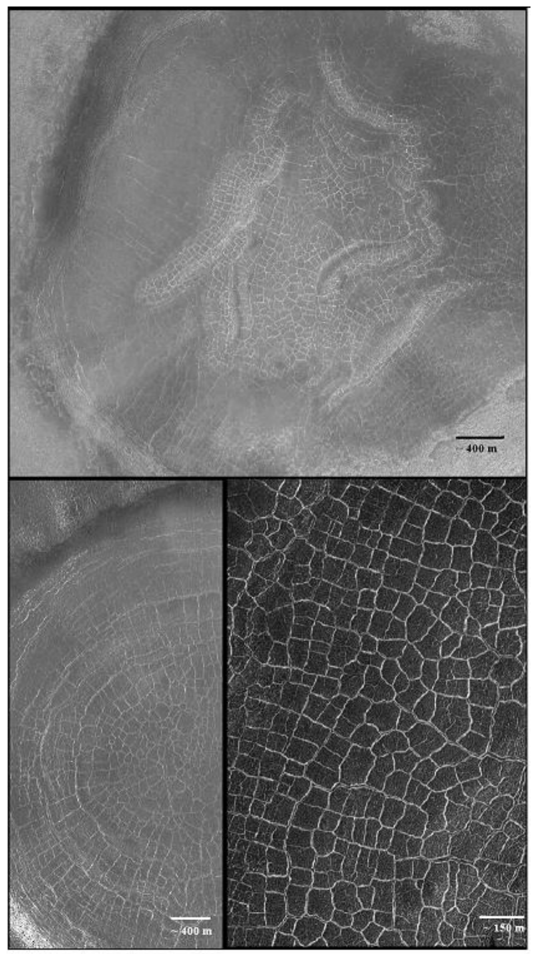

Fig.1. Various Crater-floor cracks by different imaging instruments: Upper panel: CTX. Lower left: MOC, and Lower right: HiRISE (Image IDs: MOC: M1900047, CTX: P17007514, HiRISE: PSP007372)

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Observations:

All the available MOC high resolution images (1.5-12 m/pixel) at good atmospheric conditions for latitudes from 0° to 80°N have been used for identifying the cracked patterns on crater floors, in addition to the datasets of the CTX camera (6m/ pixel resolution), and the HiRISE camera (0.3 m/ pixel resolution), that were available at the time of investigation. Fig. 1 shows examples of polygonal cracks in crater floors as seen by the different imaging instruments. Fig. 2 shows the locations of the craters that have been observed so far. It is clear that such features have a latitudinal dependence similar to other periglacial features, i.e., they are most visible in a band from 60° to 80° North. Similar mapping is being made for the southern hemisphere, but initial observations indicate that the features are following the same latitudinal trends.

Discussion & future work:

Further investigation with HiRISE camera onboard the Mars Reconnaissance Orbiter (MRO) shows that cracking patterns are extended to smaller and smaller scales in a fractal like manner within every 80-200m wide block. Mapping of the cracking features shows that they have a strong latitudinal dependence, with little or no regional or longitudinal preference. In regards to crater size dependence, there is no lower limit since these features are available in craters as small as 1 km in diameter. On the other hand, there seems to be un upper limit of almost 40 km. Craters larger than 40 km in diameter show either tentative features or none at all. There could be several reasons for that: Larger craters are generally older which may indicate that the features have eroded away with time. Another explanation is that the features are there but are obscured by glacial, or aeolian deposits, which is indeed, fairly common in high latitudes. Morphological analysis of these cracking patterns shows that indeed, it is very difficult to differentiate between the two proposed mechanisms of formation, i.e., cyclic thermal contraction versus desiccation.

Thermal contraction would imply that the features are fairly recent, and as a consequence are much younger than the craters themselves.

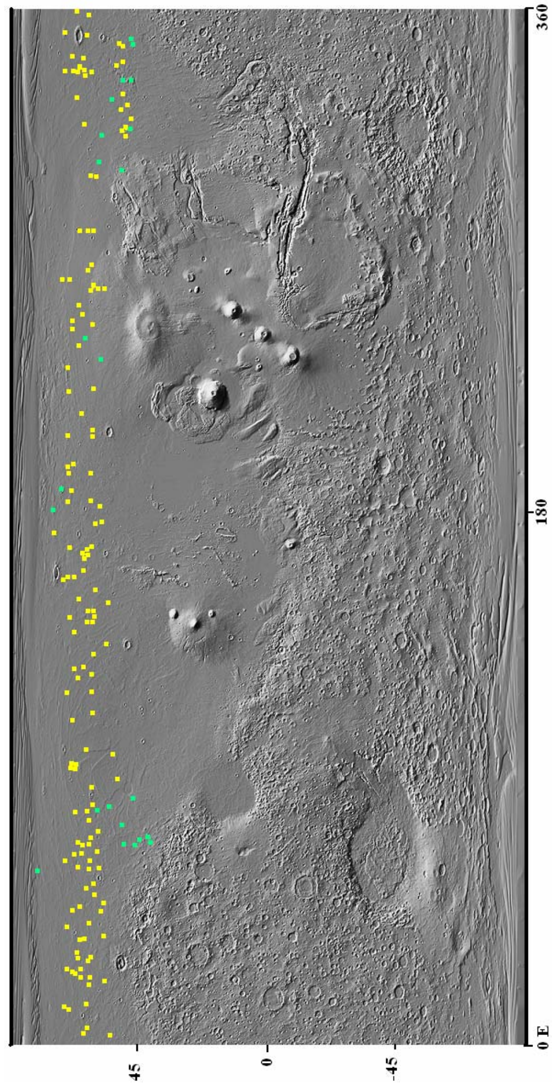

Fig.2. The map of spatial distribution of the crater-floor polygons in the northern plains on the surface of Mars. Yellow squares indicate definite observations, while green one indicate tentative signs due to erosion or the presence of a mantle material.

An important distinctive property of polygons formed in this manner is that the cracks are continuously filled with aeolian deposits, which leads with cyclic thermal contraction and expansion to the development of polygonal terrains with slightly elevated ridges in place of the deep cracks. While this seems to be evident in

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some of the crater polygons, most of the polygonal cracks show no such elevated features. Furthermore, the size of the polygons themselves is at least an order larger than typical thermal contraction polygons that are seen on Mars. On the other hand, a desiccation mechanism would imply that the ground was fairly rich in volatiles at some point, and later suffered a loss of these volatiles either through sublimation or diffusion to deeper and more stable depths away from the surface, leading to increased surface tension on the surface, that ultimately led to formation of cracked fissures to relieve the strain. An origin for the volatile rich surface inside a crater could well be an ancient lake that formed after the crater impact as a result of the impact-generated hydrothermal system, or simply the near surface circulation of volatiles by the same mechanism in smaller craters that are net expected to form a crater lake [4, 5]. Indeed, there are analogs on Earth that show similar cracking patterns in dried up lakes as seen in Fig. 3. However, this implies that a) these features are almost as old as the craters themselves, and b) there has to be a certain mechanism to explain the larger size of these features compared to the ones seen on Earth which are almost an order of magnitude smaller. We hope that the future modelling will lead to a better understanding of the favourable mode of formation which indeed is essential to understanding the evolution of these interesting features.

Fig.3. Dried-up lakes on earth as seen by Google Earth. Left Panel: Dried Karst lake in Koktoyaktuk, Canada. Polygons sizes are typically 15-20m. Right Panel: Cayote Lake, California. Polygon size range is 50-80m.

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