

**RECENT CHANGES IN SOUTH-POLAR-POLYGONAL TERRAIN DURING ONE MARTIAN YEAR: IMPLICATIONS FOR SUBSURFACE ICE-WEDGES.** S. van Gasselt<sup>1</sup>, D. Reiss<sup>2</sup>, G. Neukum<sup>1</sup>, <sup>1</sup>*Remote Sensing of the Earth and Planets, Institute for Geosciences, FU Berlin, Malteserstr. 74-100, 12449 Berlin, Germany, (vgasselt@zedat.fu-berlin.de)*, <sup>2</sup>*Institute for Planetary Research, German Aerospace Center, Rutherfordstr. 2, 12489 Berlin, Germany,*.

**Introduction:** In previous work the inventory of south polar polygonal patterns has been mapped and classified in terms of size and shape on the basis of MOC high-resolution imagery [1]. The shape and pattern of polygons, their size and trough-conjugations and intersection angles are controlled mainly by the mechanical properties of the surface and the thermal regime [2-3]. In this work we focus on seasonal observations in the south-polar region and changes of cracking patterns within one Martian year which discourage the idea of crack propagation to a notable depth as known from terrestrial recurrent ice-wedges [2-4].

**Open Issues:** The mechanisms of cracking processes of small-scale polygons in the mid-latitudes and polar regions on Mars have been discussed by several authors and models for desiccation and thermal contraction cracking [e.g., 5-6] have been proposed. However, without the knowledge of the agent, the mechanics of fracturing and the propagation depth of possible wedges, the nature of crack development cannot be determined. Indications for thermal contraction cracking processes on Mars are based upon comparisons of terrestrial analogues, they include mainly (a) sizes and intersection patterns [2-4], (b) the abundance of H<sub>2</sub>O as possible agent in the south polar subsurface as derived from measurements of H<sup>+</sup> by HEND [e.g., 7], (c) required seasonal temperature gradients which allow cracking to take place [e.g., 3]. It is expected to find similar patterns for different cracking mechanisms as contraction due to desiccation and changes in thermal regime should lead to approximately the same stresses on the surficial material.

Propagation of vertical veins with sediment- or ice-fill is one issue which must be addressed to find evidences for crack-formation by thermal contraction. Although not a requirement for the terrestrial formation of thermal-contraction cracks, evidence for the absence of vertical veins leads to the conclusion that either no ice-wedge larger than the thawing layer is present or that cracks are formed by desiccation, only.

**Observations:** As addressed in [1] the polygon-troughs have a crisp appearance and suggest recent formation on present-day Mars. On several overlapping images of the previously mapped inventory of polygonal patterned terrain, we found major changes in albedo and pattern distribution (fig. 1). MOC-image M08-07044 (257.9°E, 87.1°S) at  $L_s = 233^\circ$  shows a detail of MOC-image M03-07593 at half-resolution, taken at early spring-time ( $L_s = 185^\circ$ ) after surface frost has disappeared almost completely. The defrosted surface presents a pattern of fretted polygonal patterns with type locations south of the Chasma Australe re-entrant [1]. Typical diameters are a few meters, the polygons are homogeneously distributed across the surface. The frost-covered surface in image M03-07593 presents elongated as well as arcuate ridges building an irregular pattern of polygons. However, it is still unclear which

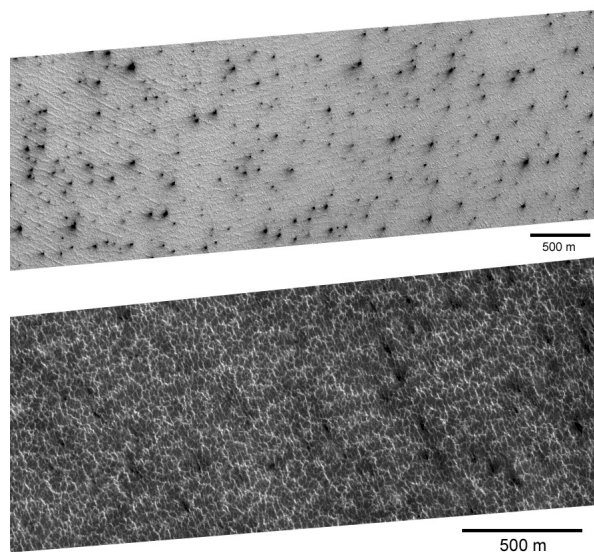


Figure 1: Center parts of MOC-NA M03-07593 (upper image) at  $L_s = 184.94^\circ$ , and MOC-NA M08-07044 (lower image), imaged at  $L_s = 233.41^\circ$ .

kind of processes have been responsible for the characteristic pattern on the defrosted surface but it is probable that there is a connection between those patterns observed on frost-covered and defrosted surfaces as similarities in surface structures in parts of the image can be observed.

Although image geometry in image 2a and 2b is slightly different, it is obvious that the polygonal patterns shown in the overlapping images received during two subsequent winters show different crack patterns. Both images are located on the residual CO<sub>2</sub> cap of the southern pole. It is noteworthy, that although the crack polygons differ, the locations of crack fields remain the same in both images throughout two years. Some of the dark troughs can be recognized in both images, but most of the troughs have vanished and new arcuate fissures have formed. This pattern differs from higher-degree cracks known from Earth, where younger troughs are formed, when stress fields change and the large polygons of earlier years are split into several polygonal cells. The style of cracking as well as the size and shape of the polygons remain identical, intersection angles are orthogonal. The surface CO<sub>2</sub>-cover does not seem to be as homogeneous as expected as fissures are curved and non-parallel to each other [4].

**Conclusions:** The crack phenomena described above lead to the conclusions that there are at least two types of contraction cracks in the south polar region:

First of all we assume that there are H<sub>2</sub>O-ice-wedge polygons in the Martian regolith, covered with seasonal CO<sub>2</sub>-frost

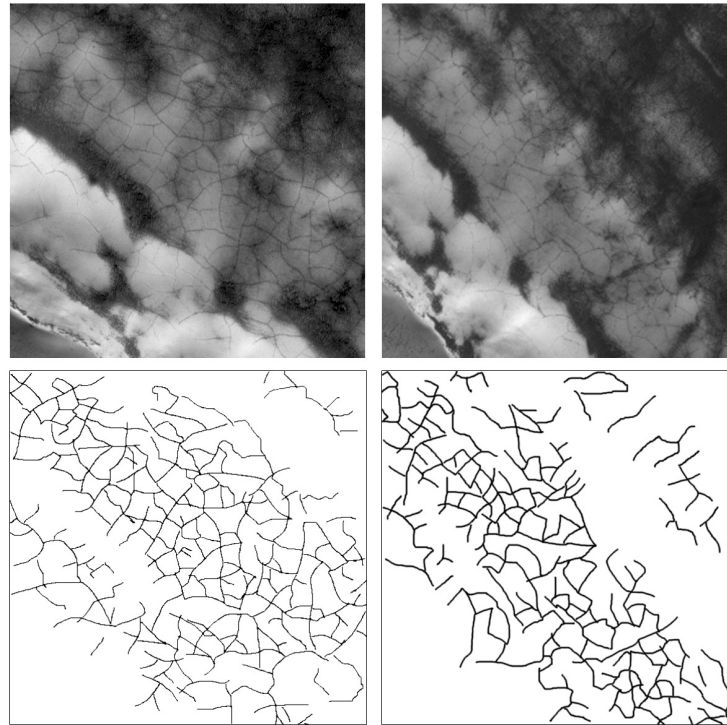


Figure 2: (a) left: M12-00730 (02/06/2000) at 1.38 m/pixel; (b) right: E11-03905 (12/26/2001) at 1.45 m/pixel, images received during southern summer ( $L_S = 297^\circ$ ), images located at 78.5W, 86.9S.

during southern winter time (fig. 1). The insulating active layer most probably does not consist of  $H_2O$ -saturated sediments but of  $CO_2$ -ice, as liquid water is not expected to be stable in latitudes below  $70^\circ S$  [e.g., 8-9]. These features could be addressed as possible ice-wedge polygons similar to those at mid-latitudes [e.g., 10-11], but seasonal changes in their morphology have not been observed yet.

Secondly, contraction cracks appear in  $CO_2$ -ice on the residual cap which seem to form in the uppermost layer of condensed  $CO_2$  each year. Their morphology resembles that of mid-latitude polygon patterns [e.g. 10]. Obviously, the  $CO_2$  cracks are not recurrent cracks in sensu-strictu [4] as the crack openings are not reactivated the following year again. Crack-depth is restricted to the seasonal layer of  $CO_2$ -ice. Therefore, most probably ice-wedges of a notable depth will not be found underneath the cracks and desiccation processes can be ruled out.

$CO_2$ -related contraction-cracking is a surficial process which assumingly occurs in subsequent years, when the layer of  $CO_2$ -ice is growing larger in winter-time and the tensile

strength of the  $CO_2$  is exceeded by the tensile stresses at low temperatures. Although thermal contraction is the main process, the polygonal patterns in regolith are most probably results of long-term and recurring thermal contraction. This question can be addressed in detail with the help of multi-temporal images of mid-latitude observations of polygonal patterns.

**References:** [1] van Gasselt et al., 3rd Mars Pol. Sci. Conf., #8088 (2003); [2] Lachenbruch, A. H., GSA Papers, 70 (1962); [3] Yereshov, E. D., General Geocryology (1998); [4] Dostovalov, B. N. and Popov, A. I., 1st Int. Conf. Permafrost (1966); [5] Mutch, T. A. et al., J. Geophys. Res., 82 (1977); [6] Lucchitta, B. K., Icarus, 45 (1981); [7] Mitrofanov, I. G. et al., Sixth. Int. Conf., #3080 (2003); [8] Haberle, R. M., J. Geophys. Res. 106 (2001); [9] Mellon, M. T. and Jakosky, B. M., J. Geophys. Res., 98 (1993); [10] Kuzmin, R. O. and Zabalueva, E. V., Lun. Planet.Sci. Conf., #1912 (2003); [11] Seibert, N. M. and Kargel, J. S., Geophys. Res. Lett., 28 (2001); [12] Kossacki, K. J. and Markiewicz, W. J., Icarus, 160, (2002);