SOUTH-POLAR POLYGONAL PATTERNS – PHENOTYPES AND LOCAL GEOMORPHOLOGIC CONTEXT.  S. van Gasselt¹, D. Reiss¹, G. Neukum², ¹German Aerospace Center, Institute of Planetary Research, Rutherfordstrasse 2, D-12489 Berlin, Germany, ²Freie Universitaet Berlin, Germany (Stephan.vanGasselt@dlr.de).

Introduction: The general shape and distribution of small scaled polygonal patterns on Mars have been attributed to ice-wedge polygons similar to their terrestrial analogs of high latitude periglacial environments, sand-wedges, desiccation cracks of dried water- or mudlakes, or to contraction cracks of cooled lava. Whatever the exact process is based on, the composition of the (sub-)surface medium, its mechanical properties, as well as the dynamics of the fracturing process still remain unknown to us. The global distribution of polygonal patterns (e.g., [1]) is in general accordance with the distribution of water and ice in the shallow sub surface of Mars, according to modelled data provided by Mars Odyssey’s HEND experiment [2] and theoretical modelling of earlier years [3], still there is a lack of evidence for polygonal patterns caused by thermal contraction cracking and the existence of ice wedges. As an approach for further understanding of the phenomena we have investigated the south polar region of Mars as a primary target for ice-wedge formation and catalogued the small-scale properties of polygonal networks and their geologic and geomorphologic context.

Geologic Settings: The south-polar region between 80°S and 90°S consists primarily of the Amazonian aged polar layered deposits (Apl) [4] and a patchy distribution of old highland terrain adjacent to the Apl materials. Towards the pole center the residual ice cap (Api) is present and shifted towards longitudes between 0°W and 90°W. At longitudes between 265°W and 90°W parts of the upper and lower Hesperian-aged Dorsa Argentea Formation are exposed (Hdu, Hdl). The areal extent of this unit corresponds with the topography in terms of elevation values of 1200 m (fig. 1). At 10°W and between 70°W to 9°W remnants of the undivided Hesperian and Noachian material (HNu) occur and show degradation by possible removal of ground ice, mass wasting and eolian processes occur [4].

Observations: From a number of ~6000 MOC-NA images between 80°S-90°S we have found over 700 images showing features of small-scale polygonal patterns. The resolution of the catalogued images ranges from 1.37 m/pixel to 14.45 m/pixel with 40% of all images ranging from 2 m/pixel to 3 m/pixel. Image acquisition ranges from L₈=7-356. The cluster effect of the distribution (fig. 1) is not bound to local settings mostly, but is constrained by the coverage density of image data of the Mars Orbiter Camera. This results in large clusters at Inca City, the Chasma Australe system and the distribution at the 87°S cirum polar circle. The geographic distribution of polygonal terrain is described in [5]. On the basis of these observations it is possible (with some restrictions concerning transitional morphologies) to distinguish at least five dominant types of polygonal patterns. About 75% of the mapped polygon types fit into this scheme, but still, in order to understand the mechanical and climatic conditions, this classification needs to be enhanced.

The polar trough type polygons (fig. 2a) are restricted to the polar layered deposits, troughs and re-entrants (Apl) of the south polar region. About 10% of the catalogued imagery show polygonal patterns on a single layer or across multiple layers. The polygons are characterized by orthogonal as well as hexagonal trough intersections with a polygon diameter of 80 m to 150 m but diameters of 20 m to more than 300 m are occasionally observed. The polygon troughs have a constant width of several meters across each investigation area, they appear fresh to moderately degraded. Only few polar layer type polygons present higher degree polygonal patterns with diameters of 5 m to 6 m within the main polygons. Lateral limitations in their extension are due to topographical steps or changes in surface material which cause changes in material strengths. The complex type polygons (fig. 2b) are a set of primary polygonal troughs and high order polygons, which vary in trough widths and
intersecting angles. The major troughs are radial to an initial crack center, the troughs are interconnected by higher order troughs orthogonal to the main troughs. Higher order troughs form intersections with lower angles. Their troughs are filled with bright frost as observations have been made within a limited seasonal period of Ls=250-290, when frost material has not been removed completely from the troughs. The polygonal features can be observed on top of the dark deposits of the Nplh, Hd(u,l), and Hnu units at 80°W and 340°W, only. The smooth plains type polygons (fig. 2c) are the commonest types of polygons and are distributed on smooth plains of average albedo values across the polar layered deposits (Apl) and on the residual ice cap area (Api). The surface topography on which they appear is flat or undulated. Commonly, they appear on small low albedo patches near the lee-ward sides of knobs or dunes. The polygonal troughs are filled with dark material and their polygons range from 20 to 60 m in average, but observations with diameters of up to 100 m can also be observed. Their trough intersections are orthogonal. The polygonal network consists either of a mixture of short straight trough segments and highly arcuate troughs or rectangular short trough polygons. The surroundings of patches with polygonal patterns are covered by deposits of eolian material and frost or they terminate at topographical steps. The regularity in terms of polygonal shape implies a homogeneous surface material in which they form [6]. Their occurrences are restricted to imagery of spring to late summer seasons. The fretted trough type polygons (fig. 2d) are characterized by small straight trough segments filled with either high or very low albedo material. The polygons extend across large areas in the Apl unit independent of the topographical situation and are situated along the 87°S circum-polar region. Their seasonal context is late southern spring to late southern summer, when the dissappearing frost uncovers the surface polygons. The short troughs show a dendritic pattern, in which short secondary (high order) troughs originate at the main trough and propagate in orthogonal direction. The size of the polygons reach up to 100 m, the side arms have lengths of a few meters only. The polygonal pattern is very distorted and interrupted, but it seems, that they originate in one point growing into a radial direction. The small side troughs are already formed in this early stage of development as it can be observed in several images. The dissected dune related type polygons (fig. 2e) are a set of small and short orthogonal troughs which have a highly uncomplete appearance. The polygons have diameters of a few tens of metres. The low albedo polygonal troughs occur between small dark patches of dune fields on a bright frost covered surface. Their appearance is bound to the 87°S-Apl units and the northernmost Nplh units. They appear throughout the seasons but the well developed polygons are restricted to about Ls=200 (early winter). At this time we can expect that the circum-polar areas are covered by large amounts of frost and that in contrast to other polygonal patterns described above, the troughs appear relatively fresh.

Conclusions: The observability of polygonal patterns and trough fill on Mars are directly tied to Martian seasons [e.g., 7]. The Amazonian polar layers and adjacent units present a variety of polygonal patterns which occur after removal of frost cover or at winter time. The characteristics in terms of shape and sizes can be attributed to the appearance of the surface material, to variations in topography and to geologic units, according to [8], but for a specification of surface material properties and crack processes data from mid-latitude areas need to be added and compared with the results for the south-polar area.