IDENTIFICATION AND CHARACTERIZATION OF SMALL-SCALE POLYGONS AROUND THE PHOENIX LANDING SITE. J. Saraiva, J. Antunes, L. Bandeira and P. Pina, CERENA, Instituto Superior Técnico, Av. Rovisco Pais, 1049-001 Lisboa, Portugal (jose.saraiva@ist.utl.pt).

Introduction: The Phoenix probe landed on the northern plains of Mars (68.2°N, 234.2°E) on May 25, 2008, and the landscape seen on the first images acquired on the surface confirmed what was already known since the HiRISE camera began scrutinizing the Martian surface with unprecedented detail, that the existence of polygonal terrains is a predominant feature in that area [1][2].

The polygons observed in this region have been recently reported to fall into two distinct dimensional classes [2]: small-scale polygons, 3 to 6 metres, with an average median axis of 4.6 meters; and large-scale polygons, 20 to 25 metres, with an average axis of 22.1 meters. The smaller polygons have generally darker contours thinner than what the resolution of MOC/MGS narrow-angle images was capable of illustrating, but now resolved in those of HiRISE/MRO. This work is the first step of a planned intensive study of the small-scale polygons present on these plains, using HiRISE images and extracting the same geometric and topological parameters as in previous studies [3][4], through automated segmentation [5] and characterization [6] algorithms.

Identification of small-scale polygons: We began by studying the polygonal network in a region of 2,600x2,600 m^2 centred in the location where Phoenix landed, contained on the HiRISE image PSP-008591-2485. Due to some constraints on computational power available the selected region (10,400x10,400 pixels) was divided into 25 square scenes, each covering 600x600 m^2 (2,400x2,400 pixels) with an overlap (E-W and N-S) between adjacent images of 100 m [7]. We created this overlap in order to count the maximum number of polygons, since the procedure employed for neighbourhood analysis [6] only uses complete polygons, i.e., the polygons cut by the edges of the images and their neighbours are not counted to avoid bias on the measurements.

The polygonal network is visually homogeneous and occupies all the area. Although the small-scale polygons are not equally discernible in every region of the image, in most of the cases the edges are clearly detected; even taking into account the cases in which the identification of polygons is uncertain, the global segmentation performance is very good. An example of this detection is presented in Figure 1. The use of this automated approach permitted us to identify some 450,000 polygons in the 25 square scenes, with about 17,500 polygons per each 600x600 m^2 region.

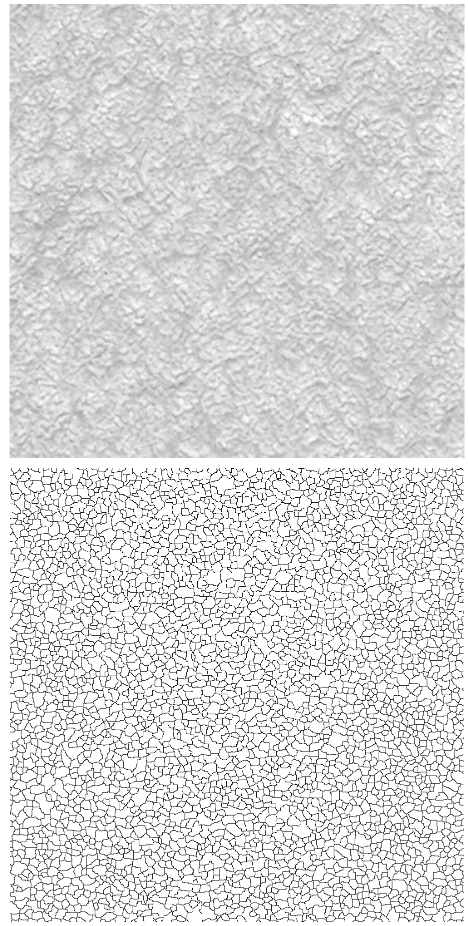

Figure 1. Small-scale polygon detection on HiRISE image PSP-008591-2485. Top: image detail (side is 250 m on the terrain); Bottom: corresponding segmented network (edges with 1 pixel thickness).

Characterization of small-scale polygons: We computed some geometric and topological parameters of the polygons, whose ranges of variation are indicated in Table I. To obtain the dimension of a polygon (L_{mean}), we averaged the lengths of the two axes measured in each case: the major axis and its perpendicular bisector. The average size of the polygons in this region is slightly above 4.50 m, which is in complete agreement with a previous study [2] but is now supported by much stronger statistics. Size distributions are presented in Figure 2: the red thick curve is the average for the whole area (2,600x2,600 m^2) while each black thin curve represents the distribution within each of the 25 images (600x600 m^2). The distributions are very much identical, confirming the great homogeneity of polygon dimension in the area.

Table I. Range of variation for the measurements performed within each 600x600 m^2 region.

Parameter	Min	Max
Area of the network (km^2)	0.3248	0.3274
# of polygons	16835	18249
Average axis (m)	4.5808	4.7813
# of neighbors	3	14
Average # of neighbors	5.9706	5.9858
Variance of # of neighbors	1.3945	1.4801
Density (# polygons/km^2)	51741	55938
Lewis' law constant	0.3375	0.3939
Lewis' law fitting	0.9225	0.9672
Desch's law constant	0.1914	0.2208
Desch's law fitting	0.9403	0.9825
Aboav-Weaire's law constant	0.9054	1.0785
Aboav-Weaire's law fitting	0.9960	1.0000

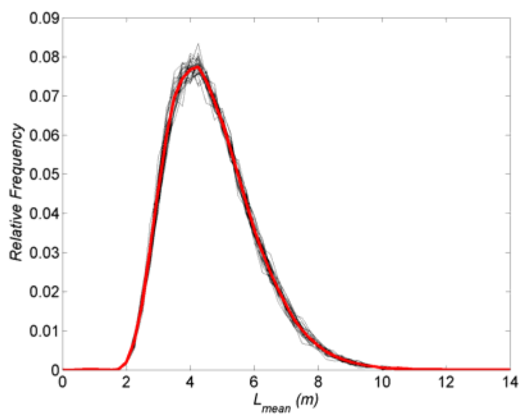

Figure 2. Size distribution of small-scale polygons (mean axis) for each 600x600 m^2 scene (black thin lines) and for the whole 2,600x2,600 m^2 region (thick red line).

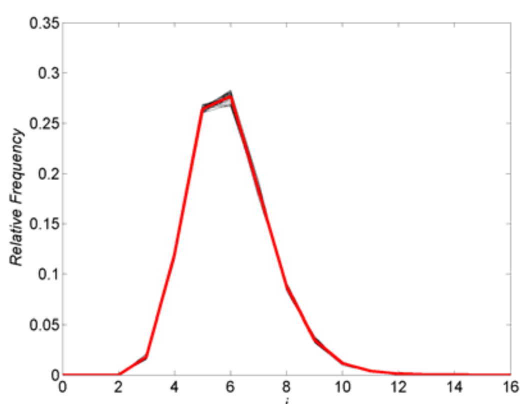

Figure 3. Distribution of the average number of neighbours for each 600x600 m^2 region (black thin lines) and for the whole 2,600x2,600 m^2 region (thick red line).

In what concerns topological features, we have computed the number of neighbours of each polygon in the network. This permitted us to again verify [3][4] the applicability of some classic topological laws that describe the correlation between the area or perimeter of a polygon and its number of neighbours (respectively, Lewis and Desch laws), and between the number of neighbours of a polygon and the average number of neighbours of its neighbours (Aboav-Weaire law). The number of neighbours of a polygon varies between 3 and 14, and approximately respects the hexagonal habit, with a strong consistency between images (average values range between 5.97 and 5.99), as presented in the "histogram" of Figure 3 (a continuous curve was drawn instead of a bar chart, so that the very high similarity between the individual regions and the average results could be better noticed). The three mentioned laws are also experimentally verified (the quality of the fitting, measured by R^2, is above 0.92 for the Lewis law, above 0.94 for the Desch law and above 0.99 for the Aboav-Weaire law), and the respective parameters (one per law) fall within the intervals of variation previously obtained for Martian polygonal networks [3]: the Lewis parameter varies within the interval 0.34-0.39, the Desch parameter is about half of that, 0.19-0.22, while the Aboav-Weaire parameter lies in the interval 0.91-1.08.

Future work: This study around the site where Phoenix landed is the starting point for an intended full characterization of the polygonal networks occurring on the northern plains of Mars that we have undertaken [7]. It clearly illustrates the advantages of using our automated approaches in the investigation of this type of feature, since it allows us to make a detailed cartography of the networks, even though they include large numbers of individual polygons occupying extensive areas, and thus to probe into the models currently most widely accepted for their origin, namely the thermal contraction of a permafrost layer [2].

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References: [1] Levy et al. (2008) *GRL*, 35(4):L04202. [2] Mellon et al. (2008) *JGR-Planets*, 113:E00A23. [3] Pina et al. (2008) *PSS*, 56(15):1919-1924. [4] Saraiva et al. (in press) *Phil. Mag. Lett*. [5] Pina et al. (2006) *LNCS*, 4142:691-699. [6] Bandeira et al. (2008) *LNCS*, 5197:398-405. [7] Pina et al. (2009) *LPS XL* (submitted).