CHARACTERIZATION OF POLYGONAL TERRAINS ON MARS. P. Pina, L. Bandeira, J. Saraiva and J. Antunes, CERENA, Instituto Superior Técnico, Av. Rovisco Pais, 1049-001 Lisboa, Portugal (ppina@ist.utl.pt).

Introduction: After early attempts at the qualitative description of polygonal terrains on the surface of Mars, quantitative descriptions have been performed by several authors using mainly geometric features [1-4] and also, in a case, topological properties [5], but always with very little statistical significance. The use of an automated approach to achieve the segmentation of the networks [6], [7], permits the analysis of a high number of features in large datasets. This work shows, with a small number of diversified networks, the geometric and topological features that we intend to extract from polygonal networks visible in MOC narrow-angle images, with the objective of classifying them and achieve a good level of statistical significance.

Geometric features: These include the computation, for each polygon, of area, length of main axes, shape factor, orientation, length and regularity of edges, internal angles, type of vertices and statistics for each network (range, average, variance).

Topological features: These features are based on the computation of the number of polygons in the neighbourhood of each polygon. With those measurements we can test two classic laws that have been observed in several biological tissues and other granular materials and that are considered to be of general applicability to 2D random networks. The first of these is the Lewis law [8], [9], which analyses the behaviour of the polygons with i neighbours in the network as a function of their average area $<A>_i$:

$$<A>_i = <A>[1+\lambda(i-6)]$$

where $<A>$ is the average area of all polygons in the network and λ is a constant. The second, the Aboav-Weaire law [10-12], investigates the correlation between polygon neighbours and the average number of sides m_i in polygons adjacent to i - polygons:

$$m_i = 6 - a + \frac{6a + \mu_2}{i}$$

where a is a constant and μ_2 is the variance of the distribution of the number of neighbours i.

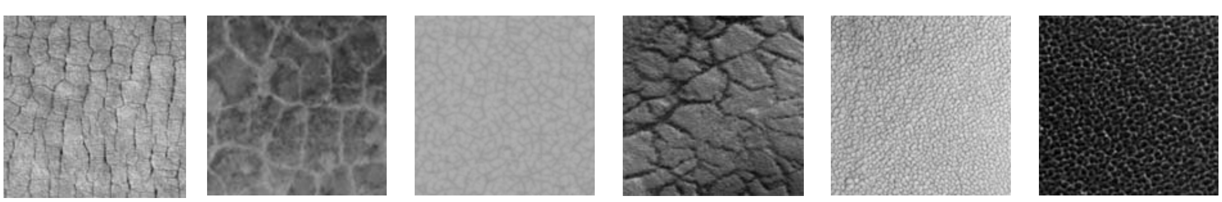
If the measured relations are approximately linear (i with $<A>_i$ in Lewis law; m_i with $1/i$ in Aboav-Weaire law) we are able to compute the corresponding parameters (λ and a) and describe globally each network with a few topological parameters.

Results: We are currently scanning all MOC N/A images above the latitude of 45º (North and South) and with a spatial resolution better than 6m/pixel. In this text we present the results obtained for a small set of images, that we considered to be representative of different types of networks [3], with the number of polygons per network ranging from tens to thousands (sampled regions of those images are presented in Fig. 1). Some of the computed values of geometric and topological nature are presented in Table 1 and lead to the following analysis:

Size: The average major (M) and minor (m) axes permit the definition of 3 clear non-overlapping size classes of polygons: small (15-30 m: images M03-04266 and M14-00154), medium (40-130 m: images M03-04331, R10-01796 and M09-01292) and large (145-185 m: R10-01555). A similar grouping according to the average areas could be also obtained, possibly dividing the medium class into 2 sub-classes.

Shape: The average shape factor (ratio between minor and major axes) is quite constant for all images and shows a clear average anisotropy for all polygons (variation between 0.66 and 0.72).

Neighbourhood: The average values computed for each network are very similar, stating that in average each polygon has about 6 neighbours or polygons around it (from 5.44 to 5.97) which was somehow expected, since in an indefinite trivalent network (three edges at each vertex) this number is equal to 6 [12]. Our networks are largely of trivalent nature (only fewer vertices are not). The networks with lower average neighbourhood values are the ones with less polygons (R10-01796 and R10-01555), which are simultaneously constituted by polygons of larger dimensions. In accordance with this, the networks with an average



M03-04331 R10-01796 M09-01292 R10-01555 M03-04266 M14-00154

Fig. 1. Details of polygonal networks extracted from MOC N/A images [NASA/JPL/MSSS].

Table 1. Measured geometric and topologic features

Image	*No. polygons*	*Area (m^2)*	*M-axis (m)*	*m- axis (m)*	*Shape factor*	*<i>*	i_{min}	i_{max}	μ_2	λ	*a*
M03-04331	438	7340.92	117.13	78.19	0.72	5.90	2	15	3.76	0.50	0.78
R10-01796	25	8633.40	126.18	87.36	0.66	5.44	3	7	1.42	0.19	0.41
M09-01292	1088	2608.60	73.52	46.36	0.70	5.95	3	12	1.92	0.41	0.74
R10-01555	47	21646.67	184.69	147.53	0.70	5.79	3	10	2.35	0.52	0.87
M03-04266	6474	262.62	22.57	15.67	0.69	5.97	3	11	1.33	0.35	1.13
M14-00154	3808	441.17	29.15	20.11	0.69	5.96	3	10	1.26	0.32	1.11

number of neighbours very close to 6 are the ones with more numerous and smaller polygons (M03-04266 and M14-00154). In what concerns the extrema, the minimum number of neighbours is 3 for all networks (a dubious situation of 2 neighbours was detected in just one network), but on the other hand the maximum value is less well constrained and ranges from 7 to 15. Consequentely, the corresponding second moments μ_2 are much wider (from 1.26 to 3.76) .

Lewis law: The plotting of the corresponding experimental values is clearly linear for each of the 6 networks (see an example in Figure 2). Then, the computation of parameter λ produces values from a minimum of 0.19 to a maximum of 0.50. Two groups of images with similar values can be noticed: M03-04266 and M14-00154; R10-01555 and M03-04331.

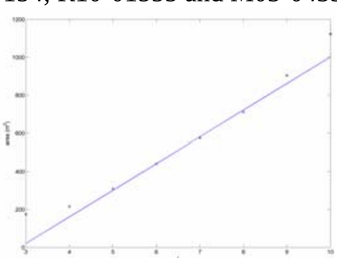


Fig. 2. Verification of Lewis law for M14-00154.

Aboav-Weaire law: The linearity of m_i with $1/i$ is also verified for all networks (example in Fig. 3), and it is possible to detect two groups on the extreme values of the computed parameter a : M09-01292 and again the same pair M03-04266 and M14-00154.

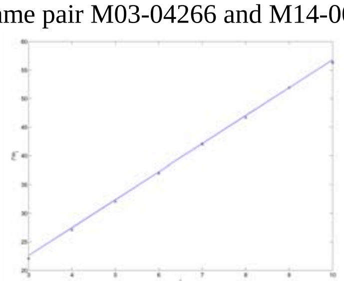


Fig. 3. Verification of Aboav-Weaire law for M14-00154.

In addition, the typical plotting of the parameters a and μ_2 permits other readings, by verifying that networks with similar properties may construct specific clusters (Fig. 4).

On-going work: The results obtained in a simple and descriptive manner for a small set of images with polygonal networks already permit to detect clear and significant differences between them, which can lead to a more objective classification of these structures into different types, related to the processes and environmental changes that led to these types of terrain. Anyhow, those hypotheses need a complete evaluation of the measured features in large image sets. Currently, besides the analysis we are performing of all MOC images (period 1998-2006) we are also analyzing similar high spatial resolution images from HRSC and HiRISE in order to cover the widest area possible and, eventually, to detect multitemporal changes within the same regions.

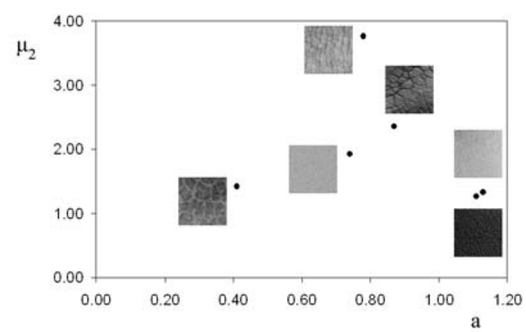


Fig. 4. Plot of μ_2 versus a.

References: [1] Seibert N. (2001) *GRL*, 28: 899. [2] Langsdorf E. (2005) *LPS XXXVI*, Abs # 2140. [3] Mangold N. (2005) *Icarus*, 174: 336. [4] van Gasselt S. (2005) *JGR*, 110, E08002. [5] Yoshikawa K. (2003) *GRL*, 30, doi:10.1029/2003GL017165. [6] Pina (2007) *LPS XXXVIII*, Abs # 1315. [7] Pina (2008) *LPS XXXIX*. [8] Lewis F.T. (1928) *Anat. Records* 38: 341. [9] Lewis F.T. (1931) *Anat. Records* 50: 235. [10] Aboav D.A. (1970) *Metallography* 3: 383. [11] Aboav D.A. (1980) *Metallography* 13: 43. [12] Weaire D. (1974) *Metallography* 7: 157.

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