MORPHOMETRIC ANALYSIS OF CLASTIC POLYGONAL NETWORKS AROUND LYOT CRATER, MARS. L. M. Brooker[1], M. R. Balme[1], S. J. Conway[2], A. Hagermann[1] and G. S. Collins[3]. [1]Department of Physical Sciences, Open University, Walton Hall, Milton Keynes, UK. (laura.brooker@open.ac.uk), [2]LPG Nantes – UMR CNRS 6112, Université de Nantes, France, [3]Department of Earth Science and Engineering, Imperial College, London, UK.

Introduction: Polygonal networks of patterned ground are commonly formed by thermal contraction of ice-cemented soils, and/or the freezing and thawing of ground ice [1, 2]. Polygonally patterned ground includes sub-types such as ice-wedge, sand-wedge, sublimation, and sorted clastic polygons [2, 3]. The characteristics of these landforms can provide information about past and present environmental conditions, with sorted patterned ground in particular thought to indicate formation in a periglacial (i.e. freeze-thaw) environment [2, 4]. Polygonal networks in the Lyot study area are enigmatic in that they contain clasts that demarcate polygon edges [5], yet are much larger than any known terrestrial examples (the polygons are ~100 m in diameter and contain clasts 5-10 m across). If these landforms are of periglacial origin, then they might indicate formation conditions met only in the Lyot area. Alternatively, these forms might indicate a different formation mechanism. To better understand how these features formed, we conducted a morphometric study of the polygonal, clastic networks around Lyot Crater using high-resolution remote-sensing data.

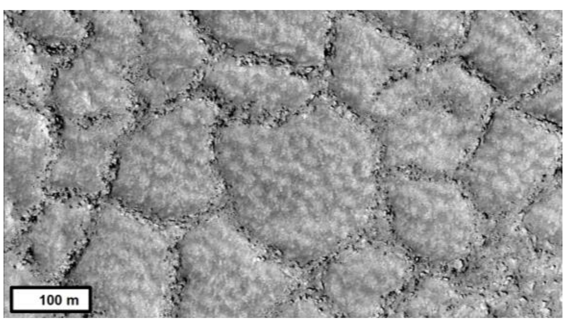

Figure 1: HiRISE image showing a section of clastic, polygonally patterned ground from the Lyot study area.

Study Area: Lyot (50°N, 30°E) is a ~215 km diameter, late-Hesperian impact crater located north of Deuteronilus Mensae [5-8]. Lyot has an extensive ejecta blanket composed of an inner continuous ejecta sheet and hummocky outer ejecta [5, 7, 8]. To the north, west and east of Lyot are large outflow channels that extend >300 km beyond the ejecta margin [7]. These might have formed by groundwater release during the impact event [5, 7]. Previous work has revealed landforms and landscapes that are morphologically similar to those formed by glacial, periglacial and fluvial processes on Earth [9]. Thus, landforms in the Lyot area appear to record the action of both ancient water sourced from underground, and more recent water sourced from the atmosphere [9].

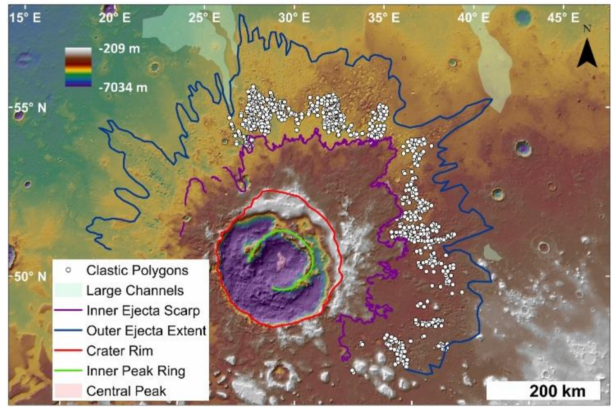

Figure 2: MOLA topographic map showing Lyot crater with clastic polygon distribution, ejecta extents and large channels marked.

Data and method: Clastic polygonal networks were analyzed using HiRISE images (~30 cm/pixel [10]). Eight HiRISE images cover clastic polygonal networks in the study area. Five are clustered within the same area, of which two overlap each other.

Our method is based upon [4] and manual digitization of polygons was performed using ArcMap 10.1 software. Only clearly recognized polygon edges, reliably interpreted as clastic in nature, were mapped. Such edges were digitized along their centre-lines, with start and end points marked at the intersection of other polygon edges. These lines are considered to be a 'polygon' if the lines form a continuous, closed feature.

For each polygon, morphometric parameters were calculated and extracted within ArcMap. Dimension parameters include area, perimeter, length, width and size [4]. Shape parameters include circularity, aspect ratio and thickness ratio [4]. Orientation of polygon long-axis was also calculated. Next, whole-network characteristics were analyzed by calculating intersection angles and intersection type (i.e. number of polygon sides intersecting at a point).

Finally, the length and width of the five largest clasts in a polygon was measured for 15 polygons selected randomly from each HiRISE image. This provides an approximation of the variation in clast size across the polygonal networks.

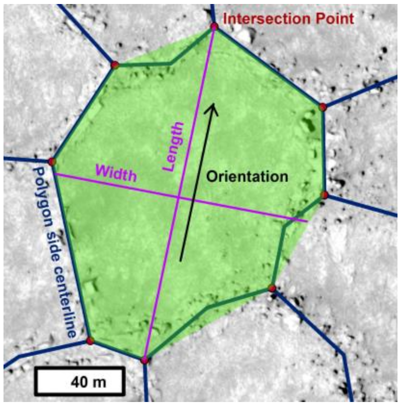

Figure 3: HiRISE image of digitized clastic polygon in Lyot study area displaying the scheme of extracted width, length and orientation values.

Clastic Polygonal Networks: The clastic polygonal networks are common within the study area. Mapping indicates that they are located in a band from the north to south-south-east of the outer ejecta, generally on areas of higher topography [5, 9]. The clastic polygons are commonly 4 or 5 sided and 100 – 200 meters in diameter, with clasts ranging up to 15 meters in size. Clasts commonly appear to be draped by mantle material and are often square in shape. Sometimes, they are arranged as double rows of elongated ridges, rather than individual clasts. This might indicate that clasts are derived from ridges that have been fractured into regular blocks of material.

Polygon intersections can be irregular in angle, though they tend towards 120°. Intersection types are usually three-ray intersections, indicating that networks are commonly hexagonal in nature. Hence, if the mode of formation was based on fracturing, the cracks probably developed more or less simultaneously [11].

PARAMETER	MEAN	STANDARD DEVIATION
Polygon Size (m)	129.6	55.5
Polygon Circularity	0.71	0.12
Intersection Angle (°)	116.3	34.5
Clast Length (m)	4.8	2.4
Clast Width (m)	3.2	1.5
% 3-ray Intersections	93.0	N/A
% 4-ray Intersections	6.9	N/A

Table 1: Summary of parameters calculated and extracted from 2742 clastic polygons.

On Mars, clasts demarcating polygon edges have been explained by various mechanisms: freeze-thaw cryoturbation processes [12, 13], frost-creep [12], CO_2 "ratcheting" [14], or gravitational slumping whereby boulders fall into thermal contraction cracks [3]. Our observation of both clasts and paired ridges demarcating polygon edges suggests another mechanism: the clasts are the results of infill of polygonal fracturing within/into the substrate, followed by differential erosion that exposes the polygonal networks on the surface. It is difficult to imagine how such a distinctive, localized hexagonal pattern would occur if the fractures were deep and were infilled by, for example, precipitation from groundwater flowing through joints. However, infill of surface fractures is a possibility.

In this scenario, polygons result from the infilling of earlier thermal contraction crack networks by material such as wind-blown sand. Compression or cementation of this infilling material leads to the formation of a polygonal network of resistant fill material. Finally, deposition of mantle units causes partial or complete burial, and then later erosion/ablation leads to exposure, fracturing and alteration of the fracture-fill to form exposed, angular clasts. A difficulty faced by this formation mechanism is an explanation of the large diameters of the polygons, as terrestrial examples are found only up to a few decameters in diameter [4]. In Utopia Planitia, however, thermal contraction polygons with diameters of 30 – 150 m across have been observed, providing a possible analogue [15].

Summary and Future Work: Clastic polygonal networks in the Lyot study area are enigmatic features. The distribution of these landforms indicates that the conditions for formation are only met in a specific area, and that there is a genetic relation between the networks and the outer ejecta material [9]. Quantitative study of these clastic polygons, combined with morphological observation, provides information by which a possible formation mechanism can be considered. Future work will involve the detailed comparison of these data with measurements from terrestrial networks and other areas of Mars, to better constrain the formation mechanism.

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