BOULDERS ABUNDANCES AND SIZE-FREQUENCY DISTRIBUTIONS ON MARS: THE 2020 EXOMARS LANDING SITE - OXIA PLANUM.

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Introduction: In 1965, the first unearthly boulders were revealed on the lunar surface thanks to the Ranger probe photographs [1]. Nowadays, the size-frequency distribution (SFD) of boulders present on the surface of a planetary body is a widely accepted and useful tool to test and investigate the geomorphological processes that occurred, or are still occurring, on its surface (e.g. [2] [3]). This approach has been used also on natural satellites (e.g. [4]), asteroids (e.g. [5]) and on cometary nuclei (e.g. [6]).

For the specific case of Mars, multiple studies have related the derived SFD of boulders not only to impact cratering, but also to erosive and depositional phenomena, as well as to aeolian processes. In addition, thanks to the availability of in situ data obtained by landers and rovers, it has been demonstrated that boulders are fundamental science targets that contains information both on the formation processes on Mars and on the mineralogy and geo-chemistry of its surface. Moreover, the analysis of the boulder SFDs and densities is fundamental for the safety of a landing probe as well as to the roving [2]. This aspect is one of the pivotal engineering constrains in a landing site selection process.

Here we present an analysis of the boulder abundances and their SFD of a study area located inside the landing ellipse of the primary candidate for the ExoMars 2020 mission, namely "Oxia Planum".

Study area: The analyzed sector is part of the "Oxia Planum" region, that lies between the southern highlands of Arabia Terra and the northern plains of Chryse Planitia (Figure 1). The whole region is dissected by several outflow channels, the two main examples being the Ares Vallis, located 350 km to its south-west, and the Mawrth Vallis, 430 km to its north-east (Figure 1).

A geological analysis based on bibliographic data, as well as on geomorphological observations, has been carried out in the study area. The geologic units were mapped on the basis of the different surface texture, their relief and albedo. The considered sector proved to be constituted by two main geological unit: a Noachian (3.9-4 Ga [7]) clay-rich formation (Nc), with widespread presence of hydrated minerals, and the Amazonian (2.6 Ga [7]) volcanic deposits (Av), constituted by basaltic lava flows, locally covering the Nc unit.

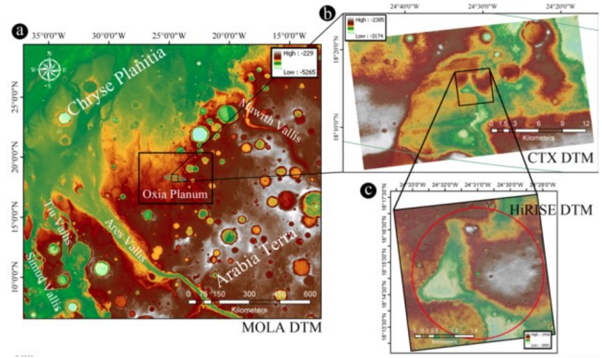

Figure 1 - (a) MOLA context map showing the location of the Oxia Planum region (black rectangle) and the landing ellipse for the ExoMars 2020 mission (light blue). (b) CTX DTM located at the center of the ExoMars landing ellipse with a spatial scale of 22 m/pixel. (c) HiRISE DTM with spatial scale of 1 m/pixel. The red circle is the study area. In (b) and (c) the green dot represents the center of the proposed landing ellipse.

Methods: In order to investigate the boulder abundances and their SFD, present on the study area, we manually identified the boulders located inside a circle with a radius of 2 km and centered on the landing ellipse center (red circle in Fig. 1c). This area, 12.57 km^2, has been selected with the primary intent of evaluating the average boulder abundances of the landing ellipse center. Moreover, the two main geological units which have been mapped in the Oxia Planum region [7] are present here, thus allowing the possibility to obtain useful insights on their evolution.

The resolution of the HiRISE image allows the detection of features down to 0.75 m in diameter (3 pixels sampling rule), nonetheless it is not uncommon in the boulder identification and extraction that more than 3 pixels, e.g. 4-7 pixels, are considered as lower boundary to provide a meaningful size-frequency statistics [6]. In order to not overinterpret the data, we assumed that the smallest considerable boulder has to be at least 1.75 m large.

The regression line used to interpolate the number of boulders per m^2 takes into account those boulders that are between 1.75 m and 6.75 m in size, since bigger ones are usually poorly statistically represented [6].

Results: Over the entire study area (12.57 km^2) we identified 8489 boulders being ≥ 1.75 m. The corresponding density per m^2 is 6.75×10^{-4} and the SFD per m^2 is -4.9 +0.1/- 0.2.

The nature of single boulders could not be inferred neither from visual examination nor mineralogical data. Since a transport origin, even if possible, seems unlikely due to the absence of any clear evidence, it seems reasonable that they are composed by the same lithology of the geological unit over which they are lying. Moreover, terrestrial craters ejecta suggests that large clasts derive from near surface regions [8]: therefore, by considering the size of the boulders involved in our study (i.e. ≥ 1.75 m), we suggest that most of them come from the near surface, corroborating the former assumption.

We grouped those boulders located on the Av and Nc unit, in order to investigate if any differences are present. On the 3.29 km^2 wide Av unit, there are 5881 boulders, with a density value of 17.88×10^{-4} boulders/m^2. The resulting power-law index is -4.8 +/-0.2. Conversely, on the 8.97 km^2 wide Nc unit, 2285 boulders have been found, with a density value of 2.55×10^{-4} boulders/m^2. The resulting power-law index is -5.5 +0.3/-0.4. All results are summarized in Figure 2.

Conclusions: The measured -4.9 SFD index may be the result of the extensive erosive processes and impacts that have occurred on the study area. It is remarkably dofferent from those obtained for the other solar system's bodies, possibly due to weathering processes and/or formation of new clasts from the bedrock erosion or the fragmentation of the bigger ones. The difference in between the two geological units is likely to be connected to the their distinct mechanical properties that may result in different production rates of boulders, even if identical conditions are assumed. Moreover, the Av unit covered the Nc one, and a heavier meteoritic influence and weathering effect can be supposed for the former.

The discussed hypotheses can only be validated by means of in situ ExoMars observations, which can provide multiple information of different terrains and textures. In addition to the scientific results, this analysis can be used as a future reference for safety engineering constraints both during the landing phase and the roving traverse to specific regions of interest.

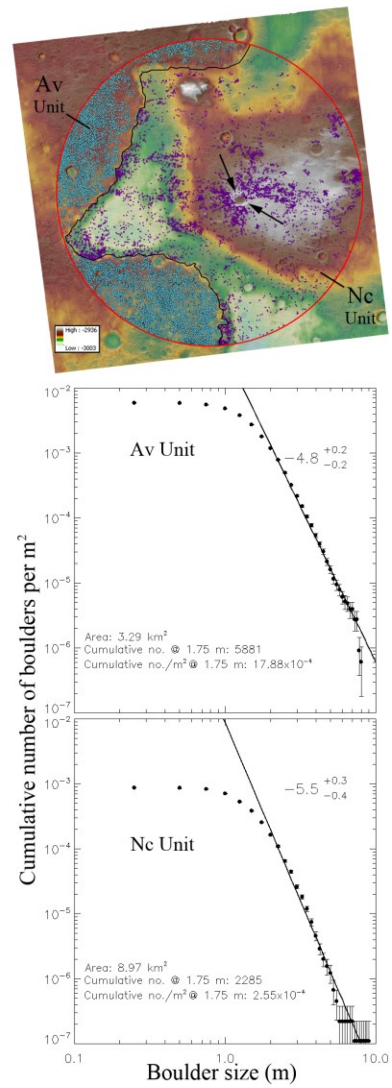

Figure 2 - Uppermost panel: HiRISE DTM showing the spatial distribution of all boulders detected, subdivided into Av unit (light-blue) and Nc unit (purple) ones. The cumulative SFD for Av (a) and Nc (b) units are presented.

References: [1] Kuiper, G. P. (1965) *The Nature of the Lunar Surface,* 99–105. [2] Golombek et al. (2008) *JGR 113,* E00A09. [3] Yingst, R. A., Crumpler, L., Farrand, W.H., Li, R., de Souza, P. (2010) *JGR 115,* E00F13. [4] Bart, G. D., Melosh, H. J. (2010) *Icarus 209,* 337–357. [5] Mazrouei, S., Daly, M.G., Barnouin, O.S., Ernst, C.M., de Souza, I. (2014) *Icarus 202,* 181–189. [6] Pajola, M. et al. (2015) *A&A 583,* A37. [7] Quantin, C. et al. (2016) *LPSC XLVII,* Abstract #2863. [8] Senthil Kumar, P. et al. (2014) *JGR 119 (9),* 2029–2059.