ABUNDANCE OF BLOCKS AND SMALL SCALE TOPOGRAPHIC RELIEFS AT THE EXOMARS LANDING SITES.

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Introduction: The ExoMars 2020 mission consists of a surface platform and a rover dedicated to investigate ancient terrains on Mars that potentially preserve chemical biosignatures [1]. For a successful landing, rover egress and rover traversability, the surface properties of the landing site are required to meet a set of criteria based on albedo, thermal inertia, terrain slope and rock abundance [1].

Here we focus on the latter property for the two final landing sites candidates of ExoMars: Oxia Planum and Mawrth Vallis [2]. As a complement to previous manual rock count studies [3, 4] we here adopt an automatic approach for the identification of blocks and small scale topographic reliefs. The smallest block size detectable with the image datasets of HiRISE is ~1.0 m. We based the retrieval of abundances for smaller rocks sizes (>0.35 m) relevant for the ExoMars mission [5] on a previously established approach [6].

Method: *Automatic identification of blocks and small scale topographic reliefs.* For the detection of blocks we followed the method described in [6,7] based on the shadow casted by rocks. Because the surfaces of the two landing sites present roughness in the form of small ridges (~1 meter wide and few meters long), the detection algorithm also considers the shadow of these features. These small but steep sloped topographic reliefs are an additional hazard to the platform and the rover and are therefore not excluded. The estimated abundance consider both floating blocks as well as ridges and/or small outcrops.

Estimation of feature sizes. The size of blocks and small scale topographic reliefs were measured in two ways. (1) By approximating their shape to an ellipse and retrieving the major and minor axes as described in [6], (2) by measuring the actual length of the shadow in the direction perpendicular to the illumination direction.

Estimation of rock abundances for sizes below the spatial resolution. As in previous studies [3,4], the estimation of block abundances at sizes below resolution is based on the method described in [6,7] that uses measured block abundances in the size range 1.5-2.25 meters. The block abundances are expressed as Cumulative Fractional Area (CFA) covered by rocks [6].

Precision Assessment: *Comparison with abundances at previous landing sites.* We tested the precision of the automatic identification of blocks by estimating the CFA at various proposed and actual landing regions for which literature estimates exist [6,7,8]: missions Viking Lander 1 and 2, Mars Pathfinder, Phoenix, MSL (Gale and Eberswalde) and InSight. Comparison with literature work (Figure 1) shows a general agreement within 0.05 (5%). Some of the discrepancies are due to (i) different count locations within a given landing site region, (ii) different techniques to calculate CFA (lookup table in [8] versus best fit in this study), (iii) size of tiles within which the CFA is estimated, (iv) different image observations and/or different image enhancement.

Strengths and weaknesses. This automatic approach allows to consistently estimate hazard abundances over large areas in a relatively short time. This property is important for the relatively large landing ellipses of ExoMars. In its current state, the method is limited in the recognition of morphological variability. For example, false positive detections are inferred wherever very low albedo eolian deposits are close to bedrock of very high albedo. The automatic approach can underestimate small rock sizes (1.0-1.5 m) relative to what is achievable with manual counts.

We noted temporal variations of CFA at the landing sites due to either atmosphere effects on shadows or changes in the eolian deposits between one to a few martian years.

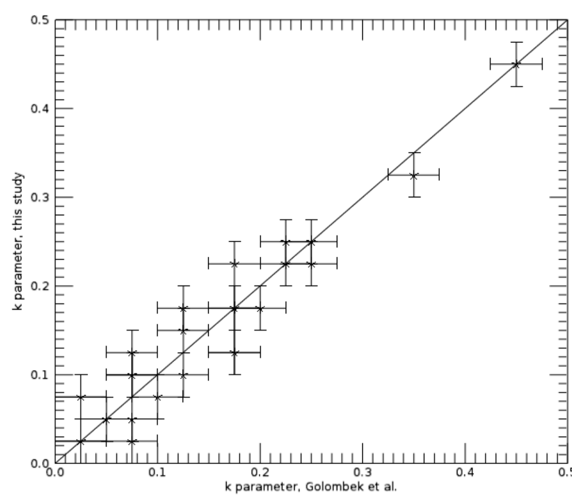

Figure 1. The k parameter refers to the cumulative fractional area (CFA) measured at 2 meters. The values used in the comparison have been taken from plots and maps in the literature [6,7,8], so that they are shown here with an uncertainty of ±2.5 %. For actual uncertainty relative to ground truth see [6].

Results at the ExoMars landing sites: We applied the automatic detection to several HiRISE images at and close to the center of the landing envelopes (Figure 2). We find that the mean CFA is similar for both Oxia Planum and Mawrth Vallis, about 7 %. The detection of areas rich in blocks (e.g., capping units in Oxia Planum, ejecta blocks of recent impacts) is qualitatively very similar to manual counts [e.g., 4]. The method is therefore useful both for abundance estimates as well as for automatic mapping purposes in very large regions where manual photo-geological investigations might require excessive time.

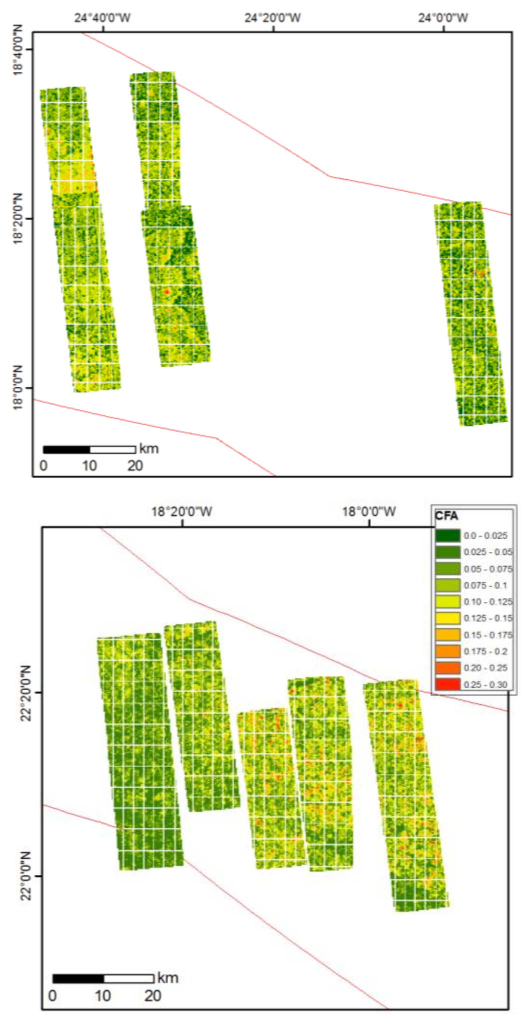

Figure 2. Cumulative Fractional Area on HiRISE images at Oxia Planum (upper panel) and Mawrth Vallis (lower panel). The center of the panels is close to the center of the landing envelopes shown in red.

References: [1] Vago et al., (2017) Astrobiology, 17, 471-510. [2] Loizeau et al., (2019) this LPSC. [3] Sefton-Nash et al., (2016) LPSC 47th, abstract #1918. [4] Pajola et al., (2017) Icarus, 296, 73-90. [5] ExoMars 2018 Landing Site Selection User's Manual (2013), ESA (EXM-SCI-LSS-ESA/IKI-003). [6] Golombek et al., (2008) JGR, 113, E00A09. [7] Golombek and Rapp, (1997) JGR, 102, E2, 4117-4129. [8] Golombek et al., (2012) SSR, 170, 614-737.