DIRECTIONAL ANALYSIS OF FRACTURES AT OXIA PLANUM, MARS A. Apuzzo[1,2] , A. Frigeri[2] , F. Salvini[1] , J. Brossier[2] , M.C. De Sanctis[2], G.W. Schmidt[1] and the Ma_MISS team[2] Dip. Scienze, Università Roma Tre, L.go S.L. Murialdo 1, I-00146 Roma, Italy (andrea.apuzzo@uniroma3.it),2 Istituto di Astrofisica e Planetologia Spaziali, INAF, Roma INAF Via del Fosso del Cavaliere, 100

Introduction: Oxia Planum on Mars is the landing site selected for the Rosalind Franklin rover mission of the European Space Agency ExoMars program [1], south-east of the Chryse Planitia Lowlands (Fig. 1). Within the scientific payload, a drilling system capable to dig a hole down to 2 meters includes a miniaturized spectrometer, the Mars Multispectral Imager for Subsurface Studies (Ma_MISS, [2]). Ma_MISS records hyperspectral data from the walls of the borehole, observing the compositional variation within the stratigraphic sequence being drilled. Olivine and phyllosilicates enriched in Fe/Mg have been mapped by hyperspectral data returned from the Observatoire pour la Minéralogie, l'Eau, les Glaces et l'Activité (OMEGA) and the Compact Reconnaissance Imaging Spectrometer for Mars (CRISM) [3]. Within the terrains at Oxia, our study focuses on the metric and decametric fractures observed with the data from High-Resolution Imaging Science Experiment (HiRISE) [4] images (0.25 m/pxl) (Fig. 2).

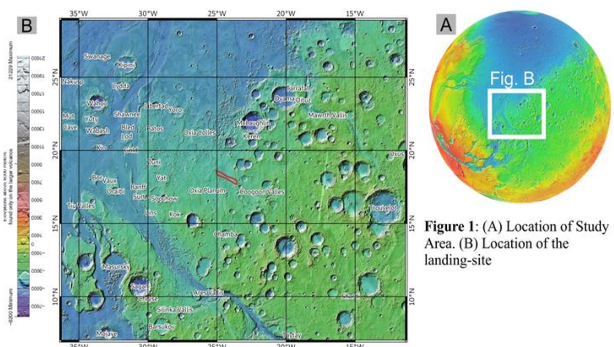

Figure 1: *(A) The location of the study area. (B) The morphology of Oxia and the south-east sector of Chryse*

Our goal is to study the directional statistics of the fractures across the entire landing site. To do this we have 1) mapped the spatial distribution of fractured terrains, 2) mapped fractures on HiRISE basemap on selected areas (scan areas, SAs), 3) compute the directional statistics of each SA and 4) mapped the spatial distribution of the average direction found for each scan area.

Methods: To record the locations of the finely fractured terrains over a large area such as Oxia landing site (about 115 by 15km) we used a grid-based mapping approach [5]: we create a grid of 1 by 1 km squares over the landing area.

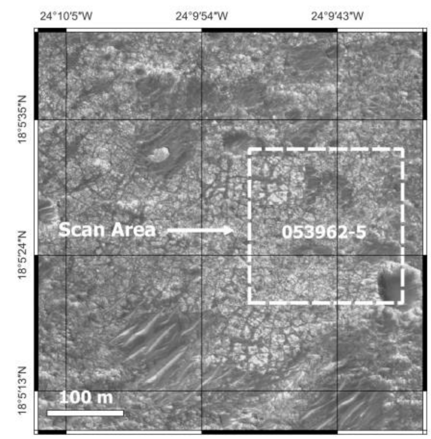

Figure 2: *Examples of fractures exposure in HiRISE images over the ExoMars landing site. The dashed white box indicates one of the scan area (SA) with its corresponding number (053962-5) where fractures were traced (the first number is referred to the corresponding HiRISE image, the second one to the number of SAs in the same HiRISE image).*

For each square we record the presence/absence of the fractures through visual inspection of HiRISE at 1:5.000 scale. Fractures in each grid-square were recorded as being either "present", "absent" or "possible." The "possible" grid-square classification was used in case of uncertainty in identification. We then selected the squares more suitable to place measurement station, where fracturing is well evident. We placed a total of 28 200x200m squared SAs (dashed white box , Fig. 2). To map the fractures we used an image processing software used in the field of structural geology, based on the Hough transform [6]. 200 by 200 meters HiRISE areas has been processed by the Slope Intersect Discrete Analysis (SID) software version 3.04-10 to tracing of the fractures. SID outputs have been converted into a vector format and processed in GRASS GIS [7]. Statistical software R (ver. 4.2.1) has been used to compute the orientation statistics [8] like the mean direction (θ) and the mean resultant length (R) of fractures traced in each SA.

Results: Results of the grid mapping (Fig. 3) indicate a widely diffused fracturing along the ExoMars landing site: fractured terrains surface referred to the "present" grid-square record at 1:5000 scale corresponds to ≈ 42% of the entire area. Noachian fractured terrains are exposed for tens of kilometers and the larger fractures are concentrated in the central-southern portion of the landing site. Results of the statistical analysis applied on 28 SAs showed an omni-directional dispersion (0-180°) superimposed to an E-W mean direction (88,47°) not evident from the morphological observation (Fig. 3).

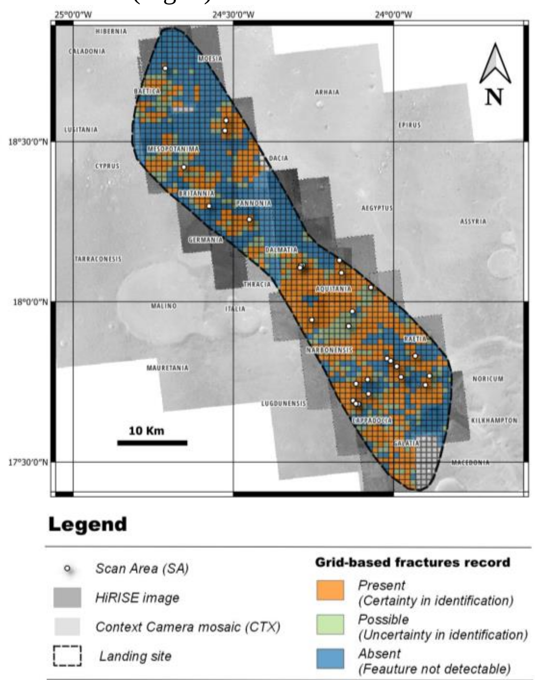

Figure 3: *Grid-mapping of the fractured terrains at Oxia Planum. Geospatial data is in simple cylindrical projection, considering Mars Sphere (IAU2018:49910) .*

Each SA shows an R value ≥ 0.5 m, meaning a highly directional component. The specific range of the mean direction (θ) combined with elevated R values indicate the presence of an anisotropic component in the orientation of the fractures. All SAs exhibit a ≈ 90° θ value, suggesting the presence of an E-W trend uniformly distributed along the entire landing site.

Discussion: Fracture patterns at any scale are widely documented on Mars and their formation mechanisms include impact processes [9] , burial and unloading of sediments [10], and contraction (i.e. desiccation and thermal-induced) [11,12]. Processes mentioned above produce disordered pattern, arranging the fractures in an isotropic mesh [13]. All these processes may be accountable of the omni-directional component (0-180°) found by the directional statistical analysis.

Stress related to tectonic activity, to impact processes, to the transmission of heat or to gravitational phenomena may add directional components to the original fracture patterns [14]. We consider the ≈ 90° directional component (E-W) as related to a stress field (e.g. tectonic activity, transmission of heat or gravitational phenomena) that influenced the direction of the fractures. The spatial distribution of the computed statistics (θ) represented by the oriented red markers in the map (Fig. 4) indicate the E-W trend as uniformly distributed along the entire study area. Our study show that fractures at Oxia present an E-W trend which is not evident at eye sight. Imaging processing showed promising results which need to be validated by comparison of statistical analysis computed with manual mapping. By improving our knowledge on fractures at Oxia we aim to support current and future studies to prepare the landing of Rosalind Franklin on Mars.

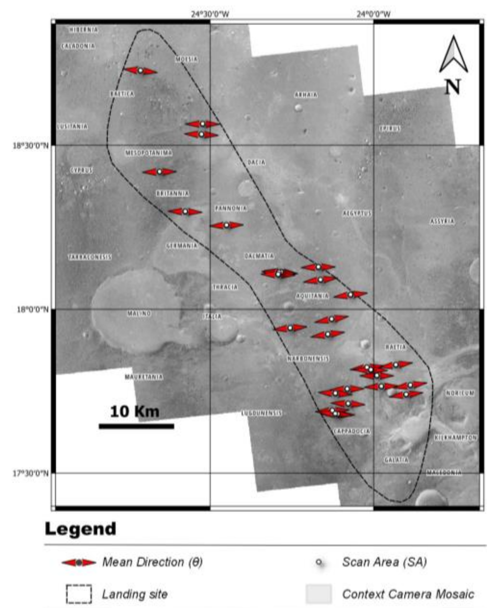

Figure 4: *Directional trends of fractures at Oxia Planum.*

References: [1] Vago et al. (2017) Astrobiology 17, 471. [2] De Sanctis et al. (2019) Astrobiology 17, 612–620. [3] Mandon et al. (2021) Astrobiology 21, 464 [4] McEwen et al. (2007) JGR 112 E05S02 [5] Ramsdale et al. (2017) Planetary and Space Science 140, 49–61 [6] Hough (1959) HEACC, Proceedings of the 2nd International Conference on HEAI [7] Neteler et al. 2013 Springer US. [8] German et al. 2013 CSMR'13 pp. 243–25 [9]Schultz et al. 1982 JGR: Solid Earth 87, 9803–9820 [10] Davis et al. 2013 Lunar Planet. Sci., XLII .[11] McGill et al. 1982 JGR: Planets 97, 2633–2647. [12] El-Maarry et al. 2014 Icarus 241, 248–268. [13] Kronyak et al. 2019 Earth and Space Science 6, 238–265. [14] Eyal et al. 2021 JSG 23, 279–296